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ART. XLIII.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXII.—*Results of Dredging Expeditions off the New England Coast in* 1874; by A. E. VERRILL.

DURING the summer of 1874 Prof. S. F. Baird, U. S. Commissioner of Fish and Fisheries, established the headquarters of the Commission at Noank, Conn., a village situated on Fisher's Island Sound, a few miles east of New London. A large party of naturalists, who were invited to take part in the investigations of the commission, availed themselves of the unusual facilities there offered for the study of marine life. The investigations of the invertebrate animals, in general, were placed in charge of the writer, but several others, especially Mr. S. I. Smith, Prof. A. Hyatt, and Mr. S. F. Clark, took a prominent part in this work. Extensive dredging operations were carried on from this station, by means of the U. S. steamer "Bluelight," under Commander L. C. Beardslee, U. S. N. These dredgings extended from 30 to 40 miles from Noank, in different directions; westward to the mouth of the Connecticut River; southward to Gardiner's and Peconic Bays and the waters south of Montauk Point; and eastward to the banks several miles south and east of Block Island, so as to connect with the dredgings of 1871. Temperatures of the surface and bottom waters were taken at more than ninety stations, and dredgings were made in a still larger number of localities.

A very large and interesting collection of invertebrate animals was secured. Among these are over 100 species new to the fauna of southern New England. Most of these are northern species, but many are undescribed. A large collec-

tion of algæ was made by Prof. D. C. Eaton and others. Prof. Baird, with several assistants, took direct charge of the fishes and fisheries, and made many interesting discoveries. He also obtained a valuable collection. A more detailed account of these investigations will be given in a future article.

During part of the month of September the Superintendent of the U. S. Coast Survey offered Prof. Baird the use of the steamer Bache, Capt. Platt commanding, to continue the dredging operations off the coast of Maine. This work was put in charge of Dr. A. S. Packard, as in 1873, and he was assisted by Mr. C. Cooke and Mr. Robert Rathburn. They made dredgings at about forty stations in the Gulf of Maine, off the coasts of Maine and New Hampshire, at various depths down to 125 fathoms. These localities may be conveniently grouped in five series.

a. Several dredgings on hard bottoms, near the Isles of Shoals and on Jeffrey's Ledge, in 25–51 fathoms (see Nos. 44, 46, 48, 77, 78).

b. An interesting series of dredgings on Cashe's Ledge, about 90 miles off Mt. Desert I., in 27 to 39 fathoms, hard and rocky bottoms.

c. One dredging on a new bank, discovered by Capt. Platt, in 32 fathoms, sandy bottom (No. 69).

d. Several dredgings in 36–48 fathoms, muddy bottoms, between Cape Ann and the Isles of Shoals (Nos. 38–41, and 78 in part).

e. Numerous localities in 50 to 125 fathoms, muddy bottoms, including most of the localities not already mentioned, over a wide area, both east and west of Jeffrey's Ledge, and extending from No. 62, off Pemaquid, Me., to the deeper parts of the Gulf of Maine, south of Cashe's Ledge.

Hard bottoms.—The collections from the hard bottoms (included under *a*, *b*, *c*) are much like those from similar and adjacent localities explored in 1873, of which nearly complete lists were published in this Journal (vol. vii, p. 502, May, 1874). Cashe's Ledge, as before, proved to be a rich dredging ground, remarkable for large numbers of rare northern species. Locality 78, in 35 fathoms, near Jeffrey's Ledge, was, properly speaking, a mixed bottom, mud predominating; but the dredge brought up some stones and large quantities of masses of firmly consolidated ferruginous mud and sand, most of which were irregularly broken and curved pieces, but some had the form of large, slightly conical tubes, 3 to 6 inches in diameter, and 12 to 15 inches long, the walls often being an inch or more thick. These are probably old uninhabited tubes of *Cerianthus borealis*, which have become firmly consolidated by some chemical action. Upon these fragments of tubes numerous species of Bryozoa, Ascidians and Sponges had established themselves,

causing the collection from this place to resemble that of certain rocky bottoms.

Table of Stations in the Gulf of Maine, where dredgings and temperature determinations were made, in 1874.

Current No.	Date. Sept.	Hour.	Locality.	Nature of bottom.	Depth in fathoms.	Temperature.*		
						Air.	Surface.	Bottom.
38	2	12 M.	Thatcher's I. Light, about 10 miles south	Soft blue mud.	41	70° F.	66°	45°
39		1.38 P.M.	Do., about 13 miles south	Mud,	48	70	69	45·5
40		2.23 "	Do., 16 miles south	Blue mud,	43	70	69	47
41		3.00 "	Do., 18½ miles south	Mud—rocks,	36–27	70·5	69	45·5
42	3	11.35 A.M.	Boon I. Lt., 6 m. N.W. by W. ½ W.	Brown mud,	68	69·5	67	52·5
43		2.32 P.M.	Boon I., N. by E.; hotel on shoal S.W. by W. ½ W.	Brown mud,	43	75	65	47
44		5.00 P.M.	Star I., S.W.; Duck I., W.	Rocky,	25	75	67·5	51
45	4	0.50 "	Boon I., 12½ miles W.N.W.	Soft mud,	88	65	67	40
46		2.28 "	Agamenticus Mt., N.W. by W. ½ W.	Hard, sandy mud,	51	65	69·5	42
47		4.00 P.M.	Jeffrey's Ledge, near last,	Sand & gravel,	25	64	58·5	45·5
48		4.30 "	Near last, Agamenticus N.W. ½ W.	Gravel,	36	64	56·5	47·5
49			Boon I., W.N.W. 27 miles,		113	64	65	40
50		7.00 P.M.	Lat. 43° 01′ 20″, lon. 69° 45′,		100	60	56	40
51	5	2.15 A.M.	Lat. 42° 56′, lon. 69° 08′,	Mud & gravel,	105	60	55	41
52		5.10 "	Cashe's Ledge	Rocks & grav.	27	60	55	42
53		7.00 "	Cashe's Ledge	Soft mud,	73	63	55	42
54		8.24 "	Do. 3½ miles N.W.	Mud,	110	61	61	42
55		2.00 P.M.	Do. 2½ miles S.	Gravel,	40	60·5	65	43
56		2.50 "	Do. 1½ miles S.S.E.	Gravel,	30	62	59	46
57		3.15 "	Near last	Rocky,	37			
57*a*		4.00 "	Near last	Rocky,	39			
58		7.00 "	Lat. 42° 03′, lon. 69° 05′,	Mud & gravel,	65	60·5	57	40
59		12.00 "	Lat. 43° 22′, lon. 69° 17′,	Mud,	92	61	55	41
60	6	4.00 A.M.	Lat. 43° 17′, lon. 69° 24′,	Mud and sand,	65	61	57	41
61		7.30 "	Boothbay, Me., harbor,		5	64	58	51
62	7		Pemaquid Pt., 10 miles N.	Mud,	48	62	62·5	47
63		0.40 P.M.	Pumkin I., 4 miles N.E.	Brown mud,	42	68	65	48
64		2.45 "	Pemaquid, 12 miles N.	Mud,	58	61·5	57	42·5
65		4.28 "	Monhegan I., 2 miles E by N.	Soft mud,	47	64·5	59	44
66	8	1.20 "	Do., 14 miles N.E. ¾ E.	Brown mud & gravel,	65	66	64	40
67		3.30 "	Seguin Lt., 19 miles N. by W.	Brown mud,	86	68	64	40
68		6.00 "	Do. N.W.; near last,	Mud,	91	64·5	59	40
69		8.30 "	Lat. 43° 11′, lon. 69° 35′,	Sand,	32	64	60	46
70		11.00 "	Lat. 43° 03′, lon. 69° 36′,	Mud,	91	61·5	58	40
71	9	1.00 A.M.	Lat. 42° 55′, lon. 69° 36′,	Brown mud,	96	61	58	40
72		4.03 "	Lat. 42° 57′, lon. 69° 50′,	" "	125	61	57	39·5
73		6.30 "	Lat. 42° 58′ 30″, lon. 70° 00′,	" "	102	62	59	40
74		8.00 "	Lat. 43° 01′, lon. 70° 09′,	" "	88	62	60	39
75		9.30 "	Lat. 43° 02′, lon. 70° 15′,	" "	92	64	64	40
76		11.10 "	Lat. 43° 03′, lon. 70° 25′,	Mud & gravel,	51	64	63	42
77		1.30 P.M.	White I. Lt., 3½ miles E. ¾ S.	Rocky,	33	69	65	44
78	12	12.00 M.	Agamenticus Mt., N.W. by N. ½ N.	Blue clay, mud and sand,	35	61·5	60	43

* I am informed by Dr. Packard that the surface temperatures cannot be regarded as perfectly reliable, for they were taken in a bucket of water in which the bulb of the thermometer was not always submerged. All the water-temperatures were taken with a Miller-Casella thermometer (numbered 18491), which was left down from 5 to 10 minutes for bottom temperatures. Our experience shows that these instruments should be down 10 to 20 minutes to insure perfect accuracy.

The following list includes the species additional to those enumerated last year. Those from Cashe's Ledge are marked C; those from Jeffrey's Ledge, J; those from Capt. Platt's new bank (loc. 69), P; those from locality 78 are marked loc. 78.

Additions to the list of hard-bottom species.

Crustacea.

Hippolyte Phippsii. C. loc. 78.
Diastylis quadrispinosa. J.
Pardalisca cuspidata. loc. 78.
Stegocephalus ampulla. J.
Epimera cornigera. loc. 78.
Monoculodes, sp. C.
Melphidippa, sp. C.
Melita, two sp. C.

Annelida.

Lagisca rarispina. J.
Nephthys circinata V. J.
Grymæa spiralis V. J.
Sabella neglecta? J.
Spirorbis valida V. loc. 78.

Gastropoda.

Bela cancellata. J.
B. violacea. C.
Aporrhais occidentalis. J.
Trichotropis borealis. C. J.
Menestho albula. C.
Adeorbis costulata. J. loc. 41.
Diodora noachina, var. princeps. C.
Onchidoris pallida. C. J. J.
Dendronotus robustus V.
Philine quadrata. C. J.

Lamellibranchiata.

Neæra arctica. P. loc. 69.
Thracia truncata. C.
Cardium Islandicum. J.
Nucula tenuis. C. J.

Bryozoa.

Discofascigera lucernaria. C. J. loc. 78.
Tubulipora serpens. J. loc. 78.
T. hispida (=T. crates St.) J. loc. 78.
T. incrassata. J. loc. 78.
Diastopora hyalina. C. loc. 78.
D. hyalina, var. simplex. loc. 78.
Discoporella verrucaria. J. loc. 78.
Cellularia scabra. P. loc. 78.
C. Peachii. C. loc. 54.
Bugula avicularia. J.
Flustra papyracea. J.
Membranipora unicornis. C. J.
M. unicornis, var. Americana. J.
Lepralia spathulifera. loc 78.
Eschara verrucosa. C. J.
E. verrucosa, v. propinqua. C. J.
E. verrucosa, var. patens. C. J.
E. elegantula. C. J.
E. lævis (=*Porella l* Sm.) C. J.
Hippothoa vulgaris. C.
H. divaricata. J.
Escharella porifera. C. J. loc. 78.
E. auriculata. C. J.
E. Landsborovii. C. J. loc. 78.
E. candida (St. sp.). C. J.
E. solida. C. J.
=*Flustra solida* St., 1853.
=*Eschara palmata* Sars, 1862.
Discopora scabra, v. plicata. C. loc. 78.
D. scabra, var. ovata. loc. 78.
D. coccinea. C. J.
D. coccinea, var. ovalis. C. J. loc. 78.
D. Jacontini (=*Escharella J.* Sm.). C. J.

Echinodermata.

Crossaster papposus. C

Hydroida.

Gonothyræa hyalina. C. loc. 69.
Clytia Johnstoni. C. J. loc. 69.
Calycella plicatilis (Sars, sp.) J. loc. 46.
Lafoëa gracillima. C.
Halecium tenellum. C.
H. sessile. loc. 69.

Muddy bottoms.—The dredgings on muddy bottoms agree closely with those of the previous year, as might be expected from the similarity of the localities, and their proximity. Most of the rare species previously obtained were again met with, so that for many species additional specimens of great interest were obtained. Thus a second specimen of *Pleurotomella Packardii* V. was dredged at loc. 54; and several of *Anachis Haliæeti* at loc. 58 and 60; *Caridion Gordoni* and large specimens of *Stegocephalus ampulla* at loc. 54 and 58, etc. A fine new species of *Asterina*, with dark dorsal spots, occurred at locality 54.

The following list includes most of the additional species, not enumerated in the lists published last year in this Journal (vol. vii, p. 411), though quite a number found on some of the muddy bottoms, but belonging properly on hard ones, are here omitted.

List of additions to the fauna of the muddy bottoms.

Crustacea.

Hippolyte polaris.	loc. 54.	Œdiceros lynceus.	loc. 41.
H. Phippsii.	loc. 54.	Syrrhoë crenulata.	loc. 41.
Crangon boreas.	loc. 41.	Metopa, sp.	loc. 54.
Stenothoë peltata.	loc. 54.	Byblis Gaimardii.	loc. 38–40.
Tritropis aculeata.	loc. 58.	Ampelisca macrocephala.	

Annelida.

Eunoa nodosa.	Amphitrite Grayi. loc. 72.
Euphrosyne borealis.	A. intermedia.
Ancistria capillaris V.	

Gastropoda and Lamellibranchiata.

Astyris rosacea.	loc. 63.	Glycimeris siliqua.	loc. 72.
Diodora noachina, var. princeps.	loc. 51.		

Bryozoa.

Diastopora hyalina.	loc. 38–40.	Bugula flexilis V., sp. nov.*	loc. 54.
Membranipora unicornis.	loc. 40.	Eschara elegantula.	loc. 62–65.

* *Bugula flexilis*, sp. nov. Plate VII, figures 1, 2.

Several rather long, slender, flexible, dichotomously divided branches radiate from close to the point of attachment, making a stellate cluster. Zoœcia in two alternating rows, smooth, oblong, slightly swollen in the middle, with a short tooth or spine on the outer angle; aperture terminal, oblique, rounded or oval. Avicularia, on the front of the zoœcia, remarkably large, nearly as broad as the zoœcia and more than half their length, compressed, fusiform, tapering gradually to the point of attachment. East of St. George's Bank, 430 fathoms, 1872; off Casco Bay, 95 fathoms, 1873; Gulf of Maine, 110 fathoms, 1874.

Discopora nitida, sp. nov. Plate VII, figure 3. From Vineyard Sound and Long Island Sound.

Easily distinguished by the very small apertures with elongated processes projecting inward from the sides; and by the acute lateral avicularia.

Lepralia Americana, sp. nov. Plate VII, figures 4, 5. =*L. Pallasiana?* V., in former papers. Long Island Sound to Beverly, Mass., low-water to 30 fathoms.

Art. XLIV.—*On the Primordial Strata of Virginia;* by Wm. M. Fontaine.

[Concluded from page 369.]

Rockfish Gap.

The railroad cuts at this place afford some good exposures of the lowest Primordial strata. In the deep cut made for the west entrance to the tunnel, the junction of these rocks with the massive chloritic argillites, which here form the mass of the Blue Ridge, is well shown. The strata are here all inverted, and dip southeast, but at a much higher angle than the Blue Ridge slates. These latter lie in heavy plates, produced by the consolidation of numerous laminæ, with a dip of about 40° southeast. As described in a previous paper, they are of a dark greenish-gray color, the green being caused by films of chlorite. They are firm and hard, resisting decomposition and degradation quite well. The first stratum of the Primordial rocks which adjoins these slates presents a strong contrast with them, the line of junction being strongly defined. This stratum, No. (1) of the section here, is composed of very thinly laminated slates or shales, much compacted by pressure. They are not crystalline and hence not true slates. They are pale yellowish-gray, and are of the variety called by the Professors Rogers, "feldspathic slates with talcose matter." They decompose, or rather lose their coherence, much more easily than the argillites. Hence at their junction with these rocks, the height of the walls of the cut suddenly diminishes from twenty to five or six feet. Thickness 300 feet. (2.) On the west of these is a band of more siliceous composition. On the side next to (1), the layers of this rock, in color, do not differ much from (1), but are thicker than the preceding slates, and more sandy. The bedding thickens, and the amount of siliceous matter increases to the west, until we have a fine-grained white kaolin sandstone in pretty thick layers. Thickness 75 feet. (3.) The last rocks are suddenly succeeded by a conglomerate of brownish red color, indicating a sudden change in the conditions of sedimentation at this point, while the two preceding rocks graduate into each other, showing a gradual change of the material deposited, which was plainly the product of slow decomposition and accumulation. Nos. (1) and (2) are the equivalents of the highly metamorphosed sandstone, No. (1), of the Balcony Falls section, while (3) is the representative of the feldspathic conglomerates and their included shales seen there. The conglomerate here presents some very interesting points of difference.

This rock is well exposed in a quarry near the railroad, from which a large amount of stone has been removed. Its structure and composition is thus fully exposed. It lies in massive plates five to six feet thick, with thin seams of shaly matter between several of the plates. These thin seams are the diminished representatives of the shales which separate the beds of conglomerate at Balcony Falls. Some small veins of quartz, the result of metamorphic action, fill cracks in the mass. The coarser materials are rounded grains of quartz of the size of a garden-pea and under. Rarely is a particle of fresh feldspar seen. This feldspar has the same character with that found in the equivalent rock at Balcony Falls. On the other hand, numerous grains and lumps of this feldspar, in a condition of almost complete decomposition, are seen. These larger particles are imbedded in a slaty cement of highly ferruginous, decomposed, felsitic matter, which when scratched with a knife gives a decided cherry-red streak. Besides, distinct particles of hematite appear. Enclosures of angular fragments of the slates of the Blue Ridge are not rare.

The more decomposed condition of this material in this vicinity is explained by the fact that it was probably brought by currents from the southwest, and thus for a considerable time subjected to agencies tending to disintegrate it. At Rockfish Gap the shores of the Primordial sea were probably formed by argillites, while farther southwest, coarse syenites containing red feldspar and quartz were washed by the waters. The fresh state of the feldspar at Balcony Falls shows that this sediment must have been rapidly formed and poured into the sea. I have already given some account of an eruptive syenite which, in the vicinity of the Peaks of Otter, has penetrated the older metamorphic syenites, and have stated also that the lowest Primordial rock at Balcony Falls has been highly altered by contact action of a similar rock. It is probable that this rock is the product of deep-seated metamorphic action, produced by the sinking, in its earliest stages, of the bottom of the Primordial sea. This would cause great pressure against the resisting syenitic border, and might fuse a portion of it and squeeze this out, shattering the upper and firmer mass. An igneous rock capable of delivering feldspathic and quartzose material exists also at Rockfish Gap, as is disclosed in the tunnel. It is, however, small in amount, and being entirely enclosed in slates, was probably not exposed to any extent to the action of the waves. There is no evidence to fix its age, but if it was formed at this period, it probably caused a fracturing of the slates, which was the source of the fragments found in the conglomerate. The thickness of the conglomerate rock is 60 feet, and like the two preceding, it has a dip of 70° to the

southeast. The strata so far form the western base of the Blue Ridge. The succeeding rocks form a series of low hills, which for a space of 2½ miles at this point lie between the mountain and the valley of South River, a branch of the Shenandoah.

(4.) We have next to the conglomerate No. (3), a partially concealed interval of 200 feet, in which the rocks are, when seen, kaolin shales and kaolin sandstone, principally the former. Hence from their softness, they occupy a valley. To the west of this is a band of kaolin sandstones, with layers of cellular, much indurated quartzite, and some subordinate beds of an indurated, gray, coarse sandstone, to be described farther on. This series, in which the quartzites predominate, has undergone much local metamorphism, apparently from hot siliceous solutions, which has rendered the material more resisting to denuding agencies. It occupies a range of hills of considerable height. It contains one bed of the gray sandstone 20 feet thick. Thickness 420 feet, or including the partly concealed band, 620 feet. This series of strata is the equivalent of No. (8) in the Balcony Falls section. The dip is high to the southeast; it is somewhat confused by the consolidation of the beds.

(5.) The first rock in this series is a highly indurated gray sandstone, the type of the beds above mentioned as forming occasional layers in No. (4). It is of dark gray color, and is composed of coarse grains which are by metamorphic action changed nearly to a compact texture. Specks of decayed feldspar occur, also numerous seams of quartz, and occasional impregnations of chlorite and epidote. The bedding is almost obliterated. This is the next most highly altered rock seen by me in the Primordial area. Next to this occurs a bed of diorite 20 feet wide, which has aided in producing the metamorphosis of the sandstone and the strata of (4). The thickness of the sandstone is 50 feet. The diorite is composed of hornblende principally, with a rather scanty amount of feldspar, apparently albite. The hornblende occurs in pretty large particles, while the albite cements them together. Next is a band of bluish-gray, coarse shales, 75 feet wide; then a partially concealed interval of 300 feet, occupied by similar rocks; then for 200 feet, several alternations of the same shales with bluish argillaceous sandstones. In these a layer 6 feet wide of red argillaceous hematite is found. Then a second bed of diorite 12 feet wide, resembling in all respects the first. All of these rocks have a comparatively low dip of from 30° to 40° to the southeast.

(6.) The above beds, which are mostly sandy shales, and are rather thickly-bedded in layers of from one to several feet, are succeeded by a band of very thinly-laminated, firm, olive

slates or shales, in which the dip rises to 75° to the southeast. These slates, which in fact are highly compressed shales, are in places much crushed, and show on their faces fine wrinkles. They are 300 feet thick. We then have 30 feet of indurated brown sandstone, with some chlorite, and a good deal of partly decomposed feldspar interspersed in it. Then an interval of concealed rock occurs for 100 feet. We then have for 150 feet several alternations of brownish argillaceous sandstones, with greenish shaly beds, in which the dip comes down to 50° southeast. Then very finely fissile, pink-colored slaty shales, which weather purplish red. Thickness 200 feet. About 50 feet (on the east side) of these shales differ from the rest in color alone, being greenish when fresh, and taking a yellow tint on weathering. Then for 100 feet a bluish shale is found. The two last series of beds, (5) and (6), appear to be the equivalent of No. (9) at Balcony Falls. Their combined thickness is about 1450 feet, that is, provided no reduplication from folding occurs. This is possible, though not probable, I think. It will be seen that these rocks are characterized by the large amount of ferruginous matter which they contain, by which they are sharply distinguished from those which precede and follow them.

(7.) The dip in the preceding series gradually declines until it attains on the west side 40° S.E., which is still more decreased in No. (7), where it varies from 30° to 40° S.E. The strata now to be described are the equivalent of the Potsdam sandstone, and resemble No. (10) at Balcony Falls in their almost total freedom from iron and other coloring matters, also in the great amount of siliceous matter and kaolin present in them. But while at Balcony Falls we find many layers of very considerable thickness to be pure quartzite, all the strata here have some kaolin, and this substance forms by far the greater part of the rock. The system here consists of a vast number of thin layers, in which we may distinguish three classes of rock. *a.* A shale, pale gray to bluish-gray when fresh, composed almost entirely of kaolin, and occurring in thin plates. *b.* This is associated with a very fine-grained kaolin sandstone, the quartz grains being now perceptible to the naked eye. The kaolin still predominates, but this rock occurs in slabs four to eight inches thick, and with *a*, forms layers or beds interstratified with *c*, which is a kaolin sandstone of moderately fine grain, and has often a thickness of several feet in the individual layers. The quartz grains are mixed with an equal amount of kaolin, which here serves as a cement for them, and forms a peculiar, mealy-looking rock, which can be easily crushed and crumbled to a loose grit. All of these varieties assumed a drab or pale yellow color on weathering,

from the oxidation of the minute amount of iron present. *c* is almost always present in some portion of the Potsdam strata, and may be considered in this part of Virginia to be characteristic of this formation. So clearly marked are the features of this material that a fragment of it may be recognized at a glance wherever found. *b* and *c* are, when fresh, very light gray in color.

The entire mass of this material is so shattered and broken that it lies in angular fragments in the beds, so that it may be removed with the pick and shovel. The Messrs. Rogers, in their descriptions of the composition of the lowest Silurian strata, often speak of their containing talc and imperfectly developed feldspar, which they regard as the product of incomplete metamorphism. While it may be true that such partial regeneration of minerals may occur on the large scale in these strata, I have seen no instance of it. This "imperfectly developed feldspar" is simply kaolin, which has lost more or less of its plasticity. A qualitative analysis of a fragment of *c* gave me as essential components: 1, Uncombined silica (sand); 2, combined silica; 3, alumina; 4, a little water, and no potash. The slaty shales of No. (1) in this section, which agree with the rocks called by Prof. Rogers talcose slates, have no magnesia, but are mainly composed of combined silica and alumina, with a marked amount of potash and iron, and a small amount of water and lime. The rock, *c*, contains also a trace of iron, and a little mica in fine scales. The conglomerate near the base of the system does not contain crystalline feldspar, because of the greater metamorphic action to which it has been subjected. The finding of feldspar in all stages of decay shows that this mineral is undergoing a process just the reverse of regeneration, and that strata composed of the fresh particles of degraded crystalline rocks have been mistaken for rocks partially crystallized by metamorphic action.

The beds last described have a thickness of 300 feet, and are succeeded by a partially-concealed interval, in which 50 feet of a similar rock are shown. From this point, for the space of half a mile no cuttings exist.* The space outside of the valley in which the road runs is occupied by low rounded hills, covered to a great depth by fragments of the rock last described. So great is this mass of matter that in some places where it is removed to be used as ballast for the railroad, excavations to the depth of thirty feet do not penetrate through it. This interval up to the valley of the South Branch of the Shenandoah, so far as can be judged from the partial exposures, is occupied by No. (7). Much of the loose matter on the surface seems to have

* No reliable estimate of the thickness of (7) can be given. It is perhaps 800–1000 feet.

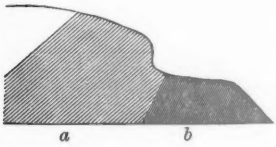
been subjected to the action of some transporting agent, since it is mixed with more or less clayey matters. Its sharp angular condition shows that it has not been moved far. Large boulders of the metamorphosed quartzite occurring in No. (4) are found in it.

Next to the hills occupied by (7) occurs the valley of the South Branch, about 500 yards wide. Here the strata are not exposed. This space was occupied entirely, or in great part, by the shales overlying the Potsdam strata. No very reliable estimate can be given of their thickness, but it cannot have been under 700 to 800 feet. They seem to have been of the same character, except the calcareous matter, with those associated with the Calciferous strata, which are found immediately on the west side of the stream. Here, at the town of Waynesboro, we have the following succession of strata, in which the dip is again high, viz: 60° to the southeast: first, purplish slaty shales, 50 feet; then dark gray, argillaceous limestone of earthy texture, 5 feet; next, greenish slaty shales, 15 feet; then dull purple, calcareous shales, 8 feet; next, very fissile, yellowish, calcareous shales, 40 feet. Argillaceous limestone follows, 5 feet thick; then very fissile, dark gray shales, 15 feet; then 10 feet of dark gray, thin-bedded limestone; then dark gray, very fissile shales again, 12 feet; lastly, slabby, argillaceous limestone, passing into the coarse, massive siliceous limestone which usually closes this series, 60 feet. It will be seen that this series is closely like that of similar age at Balcony Falls. To these rocks succeeds a wide belt of purple, greenish and gray shales, belonging probably to the same epoch. Then follows the Great Limestone of the Valley, the Auroral, or No. II, of the Messrs. Rogers.

It will be seen by a comparison of this section with that given at Balcony Falls, that the thickness of Nos. (5) and (6) in the section here is much greater than that estimated for their equivalent, No. (9), in that section. A disparity, no doubt, exists, though probably not to such an extent as it thus appears to do, since I have under-estimated rather than over-estimated the thickness of (9). Still there remains the fact that the proportion of shaly matter in the entire group at Rockfish Gap has greatly increased. This may be due to the nature of the shores of the Primordial sea, which, as we have seen, were probably composed of the fine chloritic argillites of the Blue Ridge. What could have been the source of the immense quantity of kaolin found here and everywhere in the Primordial strata, and what caused the almost total freedom of such kaolin rocks from iron, forms an interesting problem.

The following section represents the junction of No. (1) of the series with the argillites of the Blue Ridge, as seen in the

west approach to the tunnel at Rockfish Gap. At *a* are the heavily-bedded slates of the mountain, while at *b* the thinly-laminated slaty shales, the lowest of the Primordial strata, are represented.



In the two detailed sections given above at Balcony Falls and Rockfish Gap I have been thus minute in my descriptions, in order that the reader may determine for himself how far the one confirms the other. At the same time, the strata at the two places may be taken as types which best represent the normal and inverted positions, and also the changes which result from the different development of certain members of the series.

Harper's Ferry.

The exposures at this place are not sufficient to admit of a detailed section. Enough, however, may be seen to show considerable changes.

The argillites, described in a former paper, extend to the west about a mile and a half from the railroad bridge. They are then succeeded by the lower Primordial strata, the change being quite abrupt. The line of junction is well shown on the Virginia side of the Potomac, on the railroad. The massive dark gray beds of argillite are seen here, with a dip of about 40° to the southeast, to abut against the highly inclined, more fragile lower Primordial strata. The change in the character of the rock is at once seen in the altered topography. The hills no longer present abrupt faces of firm rock close to the road, but recede with rounded slopes, which are so covered with earth and fragments of stone that it is difficult to find the strata *in situ*. The interval between the limestones of the Calciferous and the argillites is about 1,100 feet. These crushed rocks are succeeded immediately by a high cliff of Calciferous limestone, between whose massive walls and those of the argillites the more fragile lower Primordial rocks seem to have been compressed and crushed.

On the Maryland side the exposures are better. The rock forming the lower strata next to the argillites seems to be a variety of the lowest slates seen at Rockfish Gap. It differs from them in containing a greater proportion of siliceous matter in the form of very fine sand, intimately mixed with argillaceous matter and kaolin. This material produces a fine-grained, slaty sandstone and slate, which, when fresh, has a pale greenish-gray color, but weathers with a gray or yellowish-gray color. The dip of these strata is about 75° to the east-southeast. They, as far as seen, occupy most of the space below the Cal-

ciferous. These rocks, in their upper or more westerly portion, are succeeded by a highly-altered sandstone of brownish color and rather coarse grain. About forty feet of this are shown. It lies in rather thin laminæ, and has the same dip with the preceding. No other strata were seen until the Calciferous limestone, distant one or two hundred feet, was reached. This latter series also shows important modifications. The entire thickness of the strata lying below the Calciferous at Harper's Ferry cannot be much over 1,000 feet. So far as seen, only two varieties of rock occupy this space, viz: the slaty rocks above mentioned, which form by far the largest portion, and the sandstone, which much resembles some of the quartzites of the lower strata at Rockfish Gap. It will thus be seen that, along with the greatly diminished thickness of the formation, the disappearance of most of the coarser material seen to the southwest is to be noted here. It is not impossible that some of the beds have been engulfed in their upheaval, since on the Virginia side the manner in which the argillites abut against the Primordial indicates that the former were crowded in a solid mass over against the latter.

The Calciferous rocks at this place are almost entirely limestones. Instead of the numerous alternations of shale and impure limestone, which elsewhere form the lower beds, we have here only limestone. This is well shown in the high cliff on the Virginia side, which presents a vertical wall close to the railroad. This rock is of dark blue color, and is quite thinly stratified. The laminæ stand at an angle of about 80° E.S.E. It is much metamorphosed, with crypto-crystalline texture, and has numerous small seams of calc-spar penetrating it in every direction. Numerous small particles of fluor-spar occur interspersed in the mass. About 120 feet were seen. The only other member of the Calciferous seen here is the curious, rough, massive limestone which forms the upper member of the series everywhere, and which at every exposure presents the same physical features. This rock at Harper's Ferry contains workable deposits of iron ore. The excavations made on the Maryland side of the Potomac for the procuring of the ore have well exposed its character. It lies immediately to the west of the rock last described. From the examination made in the open cuts in the iron mine about two miles above the bridge, its character seems to be as follows: color dark gray, fracture rough and glistening, from its sub-crystalline texture. The hardness and weight are much above those of ordinary pure limestone. It lies in masses of the thickness of thirty feet and more, without bedding. Without close examination, it would be mistaken for a variety of igneous rock. The ore is an argillaceous limonite, occupying a seam varying in width

from six to ten feet. This seam is the decayed outcrop of an argillaceous layer highly charged with pyrites, for at the depth of forty feet the ore is cut off by pyrites. This, and the other features of the rock, indicate that the entire mass of limestone has been metamorphosed by the action of water holding mineral matters in solution.

To the west of this limestone the usual formation of variegated shales occurs. The thickness of the limestone seen was about ninety feet.

The section at Harper's Ferry thus indicates an increase in the proportion of fine material over that shown to the southwest, along with a great diminution in the total amount of sedimentary deposits. This fact explains the absence in Pennsylvania (as noted by H. D. Rogers) of the conglomerates which occur in Virginia, and, according to Safford, reach their greatest development in Tennessee.

I have given the above sections in greater detail than I would have otherwise done, from the fact that Prof. Wm. B. Rogers, in his Virginia reports, does not (with the exception of the strata at Balcony Falls) give detailed descriptions of the individual members, and the order of succession of the lowest Primordial strata, the nature of his report forbidding such details. With the single exception of the *Scolithus*, there are no fossils to be seen in these lower rocks which can indicate their age. It will be seen from the above notes that in Virginia we have below the Calciferous limestones a great development of sandstones, shales and conglomerates, which attain in the middle portion of the State a thickness of over 2,000 feet, and increase in the proportion of coarse materials to the southwest. They probably attain greater thickness in that quarter, while to the northeast the amount of sediment diminishes, and the proportion of fine matter increases. This change is plainly due to the increasing development to the southwest of the syenitic rocks which formed the shores of the ancient seas, and to the greater violence in that direction of disturbing forces. The Potsdam sandstone forms one of the upper members of this group. Much further study of these strata is required to settle the question whether the entire series is a great expansion of the Potsdam, or whether divisions may be made corresponding to other epochs. The fact that at Rockfish Gap, and to the southwest, a great body of ferruginous slaty shales separates the lower, highly siliceous and altered, sandstones from the upper kaolin sandstones of probable Potsdam age, seems to indicate a change in the conditions of sedimentation sufficient to justify such a division, in which the Acadian strata may be found.

General Remarks and Conclusions.

Having given the above brief indication of the possible relations of the lower Primordial strata to each other, I will devote a small space to pointing out the apparent relations of these strata to the metamorphic crystalline rocks of the Blue Ridge. I am aware of the fact that not enough has been done to justify in all cases positive conclusions.

In my paper on the Blue Ridge of Virginia, published in the January and February Nos. of this Journal, I gave a description of certain coarse syenites and granites, which, in the vicinity of Balcony Falls and the Peaks of Otter, compose a large portion of the Blue Ridge, and which appear farther to the east in the short ranges of Tobacco Row and No Business Mountains. From the stratigraphical relations and composition of these rocks, it is plain that they are of Laurentian age. Whether the gneisses along the east foot of the Blue Ridge, and the syenites near Lynchburg, which appear to break through the mass of slaty rocks which occupy most of the country, belong to this system or to the slates, remains to be determined. These Laurentian rocks evidently increase in their development from the northeast portion of the State to the southwest.

Lying along and upon the eastern slopes of the syenites of the Blue Ridge, in the region of Balcony Falls, a formation of argillites occurs, which, in the northeast, occupy the entire space up to the Primordial strata. These rocks are covered to the east by a series of mica slates, schists, gneisses, etc., disposed in a great synclinorium which has its axis in the vicinity of the Catoctin Mountains. This axis is occupied by talcose limestones, quartzites, mica slates, hydromica slates, etc., standing nearly vertical. These latter strata in every respect bear a most striking resemblance to the rocks described by Prof. Dana as found in Berkshire Co., Mass. This entire belt of slaty, semi-metamorphic strata, is bounded on the east by a line drawn from northeast to southwest, and passing through a point four or five miles west of Alexandria, the eastern part of Louisa Co., and by Columbia, on James River. It will be readily seen that these rocks have all the characteristics of the Green Mountain series. I think that in this broad belt at least two systems exist, one older than the Primordial strata, and the other composed of metamorphosed Silurian. The argillites of the Blue Ridge belong to the former. Whether these are of Laurentian or Huronian age, I cannot undertake, in the present lack of detailed examinations, to decide. Their unconformability with the coarse syenites apparently shows them to be of later formation. How much of the mica slates and schists, if any, is of the same age with the argillites remains to be seen. I need not

repeat here the evidence given elsewhere in this paper, proving that the argillites are more ancient than the Primordial rocks. The evidence for the supposed fact that the limestones and associated rocks found in the axis of the synclinorium are metamorphosed Silurian strata, is by no means so positive. The following points lead me to such a conclusion: 1. The position of the strata, since they occupy the center of the synclinorium. 2. Their nature, associations and dip. The rocks here found associated do not exist in other parts of the belt. Stated briefly, they consist of two ledges of limestone, 80 to 100 feet thick, enclosed in a vast mass of mica slate, and separated from each other by an interval of from two to three miles, principally occupied by the mica slates, in which occur two ledges of quartzite, each about 100 feet thick. This mode of occurrence indicates reduplication by folding. The dip is nearly vertical, while on each side the strata dip toward them. 3. Prof. Rogers states that in certain parts of the quartzites of this series he saw enclosed fragments of mica slate. 4. At a slate quarry in the rocks of this series, occurring in Buckingham Co., on the east of the Catoctin Mountains, Credner states that he found undoubted specimens of a cyathophylloid coral. He does not give a more particular description. He also states that they were badly preserved. I have not visited this quarry, but propose to do so. Should Credner not have been mistaken, his discovery would of course indicate the Silurian age of the slates of the quarry.

Before closing this paper, I will add a few remarks on metamorphism, suggested by my studies of the Virginia rocks. Some writers on the subject attribute regional metamorphism mainly to three agencies, viz: 1. Increased heat and pressure, caused by thick deposits. 2. The saturation of the strata with moisture. 3. The change of motion into heat, which involves a considerable disturbance of the metamorphosed region. I have not observed that close connection between the first and third of the above-mentioned agents, and the degree of metamorphism in a given region, which should exist if these bear to each other the relation of cause and effect. In order to show this, I must compare the condition of the strata in certain parts of the State, which, in the amount of metamorphism possessed by them, stand in strong contrast. For the purpose of this comparison I shall call the belt of country lying between the western edge of the great valley of Virginia and the Blue Ridge Mountains, a portion of which is described in this paper, the Primordial belt. The region extending from the Blue Ridge eastward, and bounded by the northeast and southwest line given above, may be styled the Middle belt. On the east of this belt, and between it and the Tertiary strata which extend some distance inland from the Atlantic, is a third belt, occupied by

rocks of very different character from any occurring on the first and second belts. This region may be called the Eastern belt. The general character of the strata occupying it closely resembles that of the rocks of the "White Mountain system." The structure of this belt, stated briefly, seems to be as follows: The lowest strata are certain heavily-bedded granitoid gneisses, composed of a little quartz, black mica, and the feldspars, albite and orthoclase. These show themselves abundantly near Richmond and Petersburg. Passing to the west, these strata seem to be disposed in broad undulations, which sometimes bring them up through the overlying schistose strata, especially along certain lines where true igneous eruptive rocks penetrate them. These massive beds are covered by a comparatively thin formation of typical gneisses and mica schists, abounding in quartz and mica. The overlying rocks are gneisses in the eastern portion of the belt and mica schists in the center, which become hornblendic toward the western edge. These schistose rocks are disposed for much of the distance in broad anticlinals and synclinals, the strata over considerable spaces having generally a dip of 40°–50°, except where it is steepened by the protrusion of the underlying rocks, caused by local disturbances. This entire system is remarkable for the thorough metamorphism of the rocks, all the constituents being well segregated in large particles.

Now if we compare the amount of metamorphism existing in the strata of the several belts, we shall find it increasing in a remarkable manner as we proceed from the Primordial, through the Middle, to the Eastern belt.

I have already in this paper pointed out the difference in the amount of alteration shown in associated argillaceous and siliceous Primordial beds, and stated that I have seen nowhere in the *Primordial* belt the production over extensive areas of anything more than the first stages of metamorphism. It is true that certain strata exhibit a higher degree of change, but this is always due to intensified local action. If we pass from the lowest Primordial strata into those of the Middle belt, we note an abrupt change. The metamorphism of this belt is universal, but still not complete. The rocks are all crystalline, but the individual particles are small, and the masses which they form show more or less want of cohesion. In the thin quartzites of the east slopes of the Blue Ridge the texture is compact, and impregnations of metamorphic products occur. But in the quartzites along the Catoctin Mountains we may easily detect the separate grains of sand. The mica schists and gneisses of the entire belt rarely show scales of mica more than four or five millimeters long, and quartz in free particles is not common.

The disturbance of the strata in this area is much less than that which is found in the Primordial belt. The strata over considerable spaces are disposed in wide arches and extensive rolls, lying at a comparatively low angle. Yet in such regions they are as fully changed as where they stand on end, and, indeed, are often more so. From many indications, I am convinced that the most disturbed portions were thus affected, *after* the regional metamorphism had been produced, and that these later convulsions produced only intense local change. In the absence of measurements, no positive conclusions can be drawn as to the comparative thickness of these semi-metamorphic strata, but the indications are that it does not surpass, if it equals, the united thickness of the more highly convulsed rocks which lie to the west of them.

In the Eastern belt the strata are thoroughly altered, and in the coarseness of the crystallization, and firm, unyielding character of the rock, contrast strongly with those of the Middle belt. The massively bedded, underlying granitoid rocks are apparently of different age from the overlying schistose strata, being probably Laurentian. Still, in the amount of metamorphism exhibited, they do not surpass the latter. These schistose strata, which, as previously stated, have the general character of the "White Mountain series," do not exhibit that increased amount of disturbance and of thickness that should exist if these were the principal causes of their highly altered condition. On the contrary, these deposits appear to be thinner than those of either of the other belts, and are plainly less disturbed than the Primordial strata. As to the presence of moisture sufficient to produce metamorphism, the most favorable conditions must have existed in the Primordial belt, as this is known to have been covered with the water of the ancient seas certainly to as late a period as either of the other belts.

In examining the geological structure of the State from east to west, I have not found any such connection between the flexures as would justify the conclusion of Prof. H. D. Rogers, that the Appalachian system of folds extends to the Atlantic, and that they are more compressed next to the ocean, while they open out in proceeding west. Indeed, I do not see how he himself could have come to any such conclusion, after an inspection of his "Susquehanna Section" alone.

Such a connection between the flexures of the Silurian, Devonian, and Carboniferous areas does exist, but the Blue Ridge is the initial point on the east, and it may be accounted for by the fact that their flexures were mainly produced by a common cause acting in one period.

On the contrary, the folds of the eastern belt are mostly wider than those found in the other belts, and independent of them.

ART. XLV.—*Preliminary Inquiry into the Existence of Elements in the Sun not previously traced;** by J. NORMAN LOCKYER.

IN a paper communicated to the Royal Society on December 12, 1872 (Phil. Trans. 1873, p. 253), I have shown that the test formerly relied on to decide the presence or absence of a metal in the sun, namely, the presence or absence of the brightest and strongest lines of the metal in question in the average solar spectrum, was not a final one, and that the true test was the presence or absence of the longest lines of the metal: this longest line being that which remains longest in the spectrum when the pressure of the vapor is reduced.

Of the test in question I have said in the paper already mentioned, "It is one, doubtless, which will shortly enable us to determine the presence of new materials in the solar atmosphere, and it is seen at once that to the last published table of solar elements—that of Thalén—must be added zinc, aluminium, and possibly strontium, as a result of the new method."

In order to pursue the inquiry under the best conditions, complete maps of the long and short lines of all the elements are necessary. It is, however, not absolutely necessary for the purposes of a preliminary inquiry to wait for such a complete set of maps, for the lists of lines given by the various observers may be made to serve as a means of differentiating between the longest and shortest lines, because I have also shown that the lines given at a low temperature, by a feeble percentage composition, or by a chemical combination of the vapor to be observed, are precisely those lines which appear longest when the complete spectrum of the pure dense vapor is studied.

Now with regard to the various lists and maps published by various observers, it is known (1) that very different temperatures were employed to produce the spectra, some investigators using the electric arc with great battery power, others the induction spark with and without the jar; (2) that some observers employed in certain cases the chlorides of the metals the spectra of which they were investigating,—others used specimens of the metals themselves.

It is obvious, then, that these differences of method could not fail to produce differences of result; and accordingly, in referring to various maps and tables of spectra, we find that some include large numbers of lines omitted by others. A reference to these tables in connection with the methods employed shows at once that the large lists are those of observers using great

* Extract from a memoir presented to the Royal Society in November, 1873, which has just been printed in the "Philosophical Transactions;" here cited from Nature of Feb. 25, 1875.

battery power or metallic electrodes, the small ones those of observers using small battery power, or the chlorides. If the lists of the latter class of observers be taken, we shall have only the longest lines, while those omitted by them and given by the former class will be the shortest lines.

In cases therefore in which I had not mapped the spectrum by the new method of observation referred to in my paper, I have taken the longest lines as thus approximately determined; for it seemed desirable, in view of the very large number of unnamed lines, to search at once for the longest elemental lines in the solar spectrum without waiting for a complete set of maps.

A preliminary search having been determined on, I endeavoured to get some guidance by seeing if there was any quality which differentiated the elements already traced in the sun from those not traced; and to this end I requested my assistant, Mr. R. J. Friswell, to prepare two lists showing broadly the chief chemical characteristics of the elements traced and not traced. This was done by taking a number of the best known compounds of each element (such, for instance, as those formed with oxygen, sulphur, chlorine, bromine, or hydrogen), stating after each whether the compounds in question were unstable or stable. Where any compound was known not to exist, that fact was indicated.

Two tables were thus prepared, one containing the solar, the other the more important non-solar elements (according to our knowledge at the time).

These tables gave me, as the differentiation sought, the fact that in the main the known solar elements formed stable oxygen-compounds.

I have said in the main, because the differentiation was not absolute, but it was sufficiently strong to make me commence operations by searching for the outstanding strong oxide-forming elements in the sun.

The result up to the present time has been that *strontium*, *cadmium*, *lead*, *copper*, *cerium*, and *uranium*,* in addition to those elements in Thalén's last list, would seem with considerable probability to exist in the solar reversing layer. Should the presence of *cerium* and *uranium* be subsequently confirmed, most of the iron group of metals will thus have been found in the sun.

As another test, certain of those elements which form unstable compounds with oxygen were also sought for, gold, silver, mercury being examples. None of these were found.

The same result occurred when the lines due to the jar-spark taken in chlorine, bromine, iodine, and those of some of the other non-metals were sought, these being distinguishable as a group by formation of compounds with hydrogen.

* Potassium has since been added.

Now other researches, not yet completely ready for publication, have led me to the following conclusions:

I. The absorption of some elementary and compound gases is limited to the most refrangible part of the spectrum when the gases are rare, and creeps gradually into the visible violet part, and finally to the red end of the spectrum, as the pressure is increased.

II. Both the general and selective absorption of the photospheric light are greater (and therefore the temperature of the photosphere of the sun is higher) than has been supposed.

III. The lines of compounds of a metal and iodine, bromine, &c., are observed generally in the red end of the spectrum, and this holds good for absorption in the case of aqueous vapor.

Such spectra, like those of the metalloids, are separated spectroscopically from those of the metallic elements by their columnar or banded structure.

IV. There are in all probability no compounds ordinarily present in the sun's reversing layer.

V. When a metallic compound vapor, such as is referred to in III, is dissociated by the spark, the band spectrum dies out, and the elemental lines come in, according to the degree of temperature employed.

Again, although our knowledge of the spectra of stars is lamentably incomplete, I gather the following facts from the work already accomplished with marvelous skill and industry by Secchi of Rome.

VI. The sun, so far as the spectrum goes, may be regarded as a representative of class (β) intermediate between stars (α) with much simpler spectra of the same kind, and stars (γ) with much more complex spectra of a different kind.

VII. Sirius, as a type of α, is (1) the brightest (and therefore hottest?) star in our northern sky; (2) the blue end of its spectrum is open; it is only certainly known to contain hydrogen, the other metallic lines being exceedingly thin, thus indicating a small proportion of metallic vapors; while (3) *the hydrogen lines in this star are enormously distended*, showing that the chromosphere is largely composed of that element.

There are other bright stars of this class.

VIII. As types of γ the red stars may be quoted, the spectra of which are composed of channelled spaces and bands. Hence the reversing layers of these stars probably contain metalloids, or compounds, or both, in great quantity; and in their spectra not only is hydrogen absent, but the metallic lines are reduced in thickness and intensity, which in the light of V, *ante*, may indicate that the metallic vapors are being *associated*. It is fair to assume that these stars are of a lower temperature than our sun.

I have asked myself whether all the above facts cannot be grouped together in a working hypothesis which assumes that in the reversing layers of the sun and stars various degrees of "celestial dissociation" are at work, which dissociation prevents the coming together of the atoms which, at the temperature of the earth and all artificial temperatures yet attained here, compose the metals, the metalloids, and compounds.

On this working hypothesis, the so-called elements not present in the reversing layer of a star will be in course of formation in the coronal atmosphere and in course of destruction as their vapor-densities carry them down; and their absorption will not only be small in consequence of the reduced pressure of that region, but what absorption there is will probably be limited wholly or in great part to the invisible violet end of the spectrum in the case of such bodies as the pure gases and their combinations, and chlorine. (See I, *ante*.)

The spectroscopic evidence as to what may be called the plasticity of the molecules of the metalloids, including of course oxygen and nitrogen, but excluding hydrogen, is so overwhelming, that even the absorption of iodine, although generally it is transparent to violet light, may (as I have found in a repetition of Dr. Andrews' experiments on the dichroism of iodine, in which I observed the spectrum) in part be driven into the violet end of the spectrum, for iodine in a solution in water or alcohol at once gives up its ordinary absorption properties, and stops violet light.*

A preliminary comparison of the ordinary absorption spectrum of a stratum of 6 ft. of chlorine renders it not improbable that chlorine at a low temperature is the cause of some of the Fraunhofer lines in the violet, although, as said before, I have not yet obtained certain evidence as to the reversal of the bright lines of chlorine seen in the jar-spark.

There is also an apparent coincidence between some of the faint Fraunhofer lines and some of the lines of the low temperature absorption-spectrum of iodine.

Should subsequent researches strengthen the probability of this working hypothesis, it seems possible that iron meteorites will be associated with the metallic stars and stony meteorites with metalloidal and compound stars. Of the iron group of metals in the sun, iron and nickel are those which exist in greatest quantity, as I have determined from the number of lines reversed. Other striking facts, such as the presence of hydrogen in meteorites, might also be referred to.

An interesting physical speculation connected with this working hypothesis is the effect on the period of duration of a star's

* I have since obtained the same result by observing the absorption of I. vapor in a white-hot tube.

heat which would be brought about by assuming that the original atoms of which a star is composed are possessed with the increased potential energy of combination which this hypothesis endows them with. From the earliest phase of a star's life the dissipation of energy would, as it were, bring into play a new supply of heat, and so prolong the star's light.

May it not also be that if chemists take up this question which has arisen from the spectroscopic evidence of what I have before termed the plasticity of the molecules of the metalloids taken as a whole, much of the power of variation which is at present accorded to metals may be traced home to the metalloids? I need only refer to the fact that, so far as I can learn, all so-called changes of atomicity take place when metalloids are involved, and not when metals alone are in question.

As instances of these, I may refer to the triatomic combinations formed with chlorine, oxygen, sulphur, &c., in the case of tetrad or hexad metals.

May we not from these ideas be justified in defining a metal, provisionally, as a substance, the absorption-spectrum of which is generally the same as the radiation-spectrum, while the metalloids are substances the absorption-spectrum of which, generally, is not the same? In other words, in passing from a cold to a comparatively hot state, the plasticity of these latter comes into play, and we get a new molecular arrangement. Hence are we not justified in asking whether the change from oxygen to ozone is but a type of what takes place in all metalloids?

My best thanks are due to Mr. R. J. Friswell for the valuable aid he has afforded me in these investigations.

ART. XLVI.—*On the occurrence of the Brown Hematite Deposits of the Great Valley;* by FREDERICK PRIME, Jr.*

THE Great or Cumberland Valley, which (under a variety of names) extends from Canada, through Vermont, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Virginia and East Tennessee to Alabama, is composed in part of limestones lying immediately above the Potsdam sandstone. Geologically, they belong to the era between the Potsdam and Trenton, and are commonly termed Calciferous. A peculiarity of these limestones is their great richness in limonite or brown hematite ores, which form a large part of the charges of the many blast-furnaces situated on their outcrops. The mines from which the ores are obtained are (properly speaking) only pits or quarries,

* A paper read before the Amer. Inst. of Mining Engineers at New Haven, Feb. 25th, 1875.

from which the ore is extracted by means of picks or shovels, powder never being employed.

The ore does not occur casually at any point in the limestone, but forms regular lines, following apparently the outcrops of certain beds. In Lehigh County, Penn., where I have been engaged on the geological survey of the State during the past season, there are three or four of these lines. During the progress of the survey I was much struck by the fact that the two most important and promising lines of outcrop were—one, at the base of the crystalline schists (forming the South or Lehigh Mountain), and overlying the Potsdam sandstone conformably; the other, near the line of junction of the Calciferous limestone with the Hudson River slates. The mines along these two lines—following the topography of the country—were in place, richer and more permanent than those of the belts between, which had been more decomposed *in situ* and were generally leaner.

A peculiarity of these two lines of outcrop, and one to which I particularly desire to draw attention, is the occurrence of what I at first mistook for a highly altered slaty limestone, but which on subsequent analysis proved to consist in great part of damourite (hydrated potash-mica). The following are analyses of this damourite-slate:

I. From Fogelsville, Lehigh County, within a few hundred feet of the contact of limestone and slate, by Dr. F. A. Genth.

II. From Hensingerville, Lehigh County, within 300 feet of gneiss, by Mr. Sydney Castle of the University of Pennsylvania.

III. From Allentown, Lehigh County, within 150 feet of contact of the limestone with Potsdam sandstone: by Mr. Pedro G. Salom of University of Pennsylvania.

IV. From another quarry close to III; also by Mr. Salom.

	I.	II.	III.	IV.
SiO_2	49·92	45·40	59·30	39·80
CO_2	----	----	----	14.40
Fe_2O_3	0·91	5·06	30·30	2·40
Al_2O_3	34·06	24·69		23·95
FeO	----	----	----	*trace*
MgO	1·77	13·56	*trace*	1·94
CaO	0·11	*trace*	*trace*	9·85
Na_2O	0·74	0·27	1·51	0·52
K_2O	6·94	5·85	6·24	3·34
H_2O	6·52	4·80	4·70	6·00
	100·97	99·63	102·05	102·20

As typical damourite contains 11·77 p. c. of potash, it is evident from the above analyses that I. contains 55·40 p. c. of damourite; II, 49·70 p. c.; III, 53·02 p. c.; and IV, 28·30 p. c.

The remainder of the slate consists of ferruginous clay, quartz, and carbonates of lime and magnesia.

I have noticed that as a rule the fresh damourite-slate can only be observed where a mine is being worked: when fresh it is white to straw-yellow in color, has a greasy feel and very slaty texture, being composed of minute crystalline plates. As soon as work is stopped in a mine the slate commences to decompose and becomes rapidly converted to a white or yellow clay, the latter color being due to oxide of iron. Indeed, in many mines no slate can be observed at all, the whole of it being changed to clay prior to the opening of the pits.

I have made a qualitative examination of both white and yellow clays from the same mine as I, and close to the spot where the slate was obtained. I found them to contain the same ingredients as I.

That the damourite-slate belongs to the Calciferous and not to the Laurentian or Huronian periods, is evident from the fact that it is found forming a bed in the limestone immediately overlying the Potsdam sandstone and conformably to the latter. The ore is always found above the clay or damourite-slate, or at least in the upper portions of it, *never* below it; and usually in streaks or masses precisely in the manner noticed by Prof. W. P. Blake* at Ocoya Creek, California; and from the manner in which the ore occurs it appears to have been deposited by the percolation of waters containing iron in solution. The ore also occurs as so-called "bombshell ore," and this ore when hollow either contains water or the clay resulting from the decomposition of the damourite-slate. The interior surface of this bombshell ore is frequently glazed, apparently by a thin coating of manganese oxides, and often contains small stalactites, the ore clearly indicating its aqueous origin, and its formation *subsequent* to the rock or clay inclosing it.

So-called pipe ore is also found,—though more rarely in this district—but under different conditions, being always found underneath a bed of limestone, and evidently formed by the percolation of ferruginous waters through this bed. I have never seen the pipe ore in large quantities at any one point or associated with the slate or clay.

If this occurrence of the damourite-slate or clay and ore was merely local, it would be scarcely worth noticing; but in fact we find that the slates or clays are almost universally associated with the iron ores of the Calciferous epoch. They are therefore of the greatest importance.

Professor Dana, in a private letter to me, mentions the occurrence of slates with the brown hematite deposit of Richmond, Berkshire County, Massachusetts. Professor Shepard,†

* See Pacific R. R. Reports, vol. v, p. 168.

† A Report on the Geol. Survey of Connecticut, by C. U. Shepard, p. 20.

in writing of the ore bed at Kent, Connecticut, speaks of decomposed micaceous gneiss (?) called by the workmen "grey fuller's earth," and also of "decomposing quartzy mica-slate." We meet with this association of slate or clay and ore in Lehigh County, Penn.

Professor Lesley also speaks of this occurrence in his "Report on the Brown Hematite Deposits of the Nittany Valley, Penn." Here there are apparently *three* lines of mines, to judge from the map accompanying the report. Professor Persifor Frazer, Jr., informs me that he found the same association of white clay with ore in York County, Penn.

Professor Lesley† gives a sketch of what he calls "ore-bearing slates" lying between the Potsdam and Calciferous of the Cumberland Valley. These are evidently damourite-slates, for he proceeds in the article to speak of white clays formed by their decomposition. The same association is found in Maryland and Virginia in the valleys forming the Great Valley.

Professor Lesley* speaks of the occurrence of white clay with ore in the same formation at Embreeville, East Tennessee. It also occurs at Shelbyville, Alabama.

It is therefore evident that the occurrence of this slate or clay with the brown hematite ores of the Calciferous epoch is the rule, its absence the exception. As Professor Lesley† says: "They (the ores) never occur in any other relationships. They are the same ores, in the same rocks, arranged in the same way, the whole distance from Massachusetts to Alabama. Consequently what is geologically true of the ore beds at Salisbury and Amenia, east of the Hudson, is true all the way to Alabama."

Formerly the slates probably covered the sides of the mountain ranges now forming their south boundary, resting on crystalline limestone, which separated them from Potsdam sandstone. On account of the large amount of carbonate of lime which the slates probably contained and the ease with which they were converted to clay, they have suffered the most in the erosion which has taken place. My own experience has been that the slate and clay occur under the ore, and *not* the reverse.

From this constant occurrence of the slate with the ore it is evident that the former has exerted an important influence on the deposition of the ores: and I think that the presence of the slate was necessary to such deposition, in that it formed an *impervious bed through which the chalybeate waters could not percolate.* Whatever may have been the manner in which the ore originally existed, it was deposited in and above the slates from an aqueous solution. Under these circumstances, it will be

* Lesley. "The Iron Ores of South Mountain in Cumberland Co., Penn.," in Proc. Amer. Phil. Soc., Jan., 1873. † Proc. Amer. Phil. Soc., May, 1872.

highly improbable that we shall find continuous deposits of the brown hematite ores when the slate or clay does not occur with them.

With respect to the quantity of ore, Professor Lesley, in his paper on the Cumberland Valley, says it will depend: "First, on the original charge of iron in the strata; second, on the dip of these strata; and third, on the depth beneath water-level to which the mouldering decomposition of the strata and the peroxidation and concentration of the iron has extended."

There is much difference of opinion as to how these deposits of brown hematite ores can have been formed. Dr. Hunt, in a paper read before the National Academy of Sciences in November, 1874, gives it as his opinion that they were once beds of pyrites in *Huronian* schists, now decayed. I have shown in the commencement of this paper that they are *Calciferous* slates or schists; and were the ores formed by the alteration of pyrites *in situ*, we should find kernels of iron-pyrites which had escaped alteration, especially in the deepest mines. This is not, however, the case. Iron pyrites are found very rarely; as, for example, in Breinig's mine near Allentown, and one of the Glendon Iron Company's mines near Easton; and these mines are not the deepest we have, the former being quite shallow.

Professor Lesley* thinks the ores "were deposits *in loco originali* of the iron (as hydrated peroxide) set free from the limestone or dolomite rocks during their gradual erosion and dissolution;" agreeing in this respect with Dr. R. M. S. Jackson, who made the first geological survey of the Nittany Valley ore beds in 1838 or 1839. Of course, only the carbonates of lime and magnesia would be dissolved; the clay, iron and silica would remain behind. Were this, however, the case, should we find *fresh, undecomposed* damourite-slate conformably in position with limestones above and below it, as can be seen at the Lehigh Iron Company's limestone quarry at Allentown, Penn.? From what I have seen in Lehigh, Northampton and Berks Counties, Penn., I have been led to the following conclusions, which I advance with considerable reluctance, as I consider it extremely dangerous to argue from observations within a limited area to general conclusions.†

* Lesley, Report on the Brown Hematite deposits of the Nittany Valley.

† Prof. C. U. Shepard, in his Report on the Geological Survey of Connecticut, published in 1837, says: "The origin of limonite in these rocks ['mica slate, micaceous gneiss or quartz-rock'] may be attributed to the decomposition of the sulphuret of iron and other ferruginous minerals with which they are known to abound. It is obvious also that, in a majority of instances, this change took place in the original repositories of these minerals; since no perceptible derangement is discoverable in the layers of the ore-bed, or want of conformity in them to the adjacent rock." This view, adding limestone to the rocks, has been found by Dana to accord fully with the various facts in the limonite region of Western Connecticut and Massachusetts.—Eds.]

The damourite-slates, being the products of the decomposition of primary rocks containing orthoclase and probably oligoclase, or albite, were deposited in the Silurian sea during the Calciferous epoch and near its commencement. At Allentown and Bethlehem, Penn., the slates are but 50 to 100 feet above the Potsdam sandstone, with a blue massive limestone, generally crystalline, between the two. Limestone was again deposited above the slate. I am not yet prepared to say whether more than one bed of damourite-slate was formed, and reserve an opinion on this point until I have made further explorations.

The brown hematites were probably formed by the oxidation of iron pyrites, but the former are not in the same place that the latter were. My reasons for this assertion are twofold. In the first place, the animal carbon of the organisms, whose shells formed the enormous quantity of dolomite or limestone, exists in such quantities throughout the limestone as to color the rock, the zinc blende (of Friedensville) and the carbonate of iron a bluish-grey. This same carbon would readily reduce the sulphate of iron carried into the ocean to iron pyrites. As a proof of this reduction I need only mention that iron pyrites have been found in the mud* of a pond. Secondly, the great majority of the brown hematites which I have had analysed, and they are many, contain a *trace* of sulphur, usually not more than a few hundredths of a per cent. I have also found minute (almost microscopic) crystals of iron pyrites in much of the limestone, where it is opened in quarries; and I have also seen in much of this same limestone, where weathered, minute cavities, which I have ascribed (perhaps erroneously), from their general appearance, to the decomposition of the pyrites.

It is at present impossible to say whether the pyrites from which the brown hematite ores were and are forming were thus minutely disseminated through the limestone, or whether there was a bed of the limestone—now decomposed,—especially rich in the pyrites.

In either case it would seem that the pyrites above water-level—and we must bear in mind the great erosion which the surface of the country has undergone since it was formed—would oxidize from the action of the water and the air carried in by it, forming protosulphate of iron. This being readily soluble in water, was carried down through the limestone, forming sulphate of lime (gypsum) and carbonate of iron wherever the solution came in contact with the fresh limestone. This reaction was, however, probably slight, owing to the rapid descent of the solution in seeking the water-level. It experienced no difficulty in its descent until it came in contact with

* Gmelin—Kraut's Handbuch der Chemie, 6th ed., vol. iii, p. 333.

the damourite-slate, when, meeting with an impervious bed, it could not descend any farther and was then obliged to follow the slates. This considerably retarded the rapidity of its flow, permitting the reaction between the limestone (and the carbonates of lime and magnesia in the damourite-slate) and protosulphate of iron to take place more completely. By this means carbonate of iron was deposited, being but slightly soluble; while the sulphate of lime (gypsum) formed, being very soluble, was carried off in solution.

No doubt many of the limestone caves—so common in the Calciferous limestones—were formed by the dissolving action of the water containing protosulphate of iron. The subsequent formation of the limonite is easily explained, being merely the oxidized and hydrated product of the carbonate of iron.

In fact, a bed of blue carbonate of iron, identical in appearance with the ordinary limestone and Friedensville zinc-blende, occurs with the brown hematite ores at Balliet's mine near Allentown and at one of the Hellertown mines near Bethlehem. It does *not* occur at many of the mines in the Lehigh Valley; those being the only mines where I know of its occurrence. The very fact of this occurrence would tend to show that the above-mentioned reaction has taken place and was the one by which the ore was formed. This reaction would also explain why the brown hematites which occur in limestone are almost always free from sulphur, merely containing a trace; and yet almost always containing *this trace*. As a proof of this, I give the analysis of a brown hematite which occurs at Katahdin Furnace, Piscataquis County, Maine. The analysis was made by Professor T. M. Drown of Lafayette College. It afforded

Fe_2O_3	H_2O and organic matter	SiO_2	H_2SO_4	P_2O_5
76·87	19·25	0·71	3·10	0·10=100·03

Professor Drown informs me that the rock underlying the ore was siliceous in character, thus giving the sulphuric acid no opportunity to combine with lime and be carried away.

The objection may be raised to this view of the case, that we do not anywhere find any deposits of gypsum. It must be borne in mind that gypsum is readily soluble, and would be carried a considerable distance in solution before being precipitated. I can also point to one very considerable deposit of gypsum in this formation; that of Saltville in Russell County, Virginia.

It may be urged—and I confess with much show of reason—that the iron was first present in the limestone as carbonate. As one example of this may be adduced the following instance, for which I am indebted to Professor Dana. "In one of the brown hematite mines at Richmond, Berkshire County, Massachusetts, there was exposed, about fifteen months ago, a great mass of massive carbonate of iron, which was once a part of the

limestone of the region. It appeared to have resisted decomposition in consequence of its compactness and purity. There is limonite of great thickness all about it, which has been made by the decomposition of the limestone and its included carbonate of iron, or its carbonate of iron and lime; for an extensive ledge of limestone rises above the great pit or excavation on its north side, whose layers are conformable to that of the massive carbonate of iron in the bottom of the mine. The material between the two must have originally been calcareous: it is now gone and there is limonite in its stead."

The fact here mentioned tends to prove that the limonite was probably originally present as carbonate of iron and that the outer and possibly less compact portion of the deposit became changed.

It seems to me that in this instance, as in those at Balliet's mine and Hellertown, we have a case of alteration of the limestone to carbonate of iron particle by particle, or, so to term it, "a pseudomorph by replacement."

My objection to the original deposition of the carbonate of iron, as such, in the Calciferous epoch is threefold. In the first place, it should be uniformly distributed through the limestone and not confined merely to the horizon just above the damourite-slates. Then there should not be even the *trace* (the few hundredths of a per cent) of sulphur in the brown hematites, which we so uniformly find. And finally, there seems to be a lack of cause, such as exists in the case of the carbonates of lime and magnesia. For these were secreted by the marine animals to form their shells, &c., which would not be the case with carbonate of iron.

In conclusion, I would once more point to the fact that whatever the origin of brown hematites may have been, the cause of their deposition, where they are now found, must have been the damourite-slates.

Lafayette College, Easton, Pa., Feb. 22, 1875.

ART. XLVII.—*Note on some New Points in the Elementary Stratification of the Primordial and Canadian Rocks of South Central Wisconsin;* by ROLAND IRVING.

THE order always hitherto accepted for the Lower Silurian strata of Wisconsin has been as follows, beginning below:

I. *The Potsdam Sandstone*—500–700 feet in thickness; in its upper portions somewhat dolomitic; fossiliferous in localities near the Upper Mississippi and St. Croix Rivers.

II. *The Lower Magnesian Limestone*—200–250 feet in thickness; chiefly a pure dolomite, and almost without fossils.

III. *The St. Peter's Sandstone*—80–100 feet in thickness; for the most part a coarse quartzose sandstone: at times with ferruginous cement, at others loose and incoherent.

IV. *The Blue and Buff Limestones.*

V. *The Galena Limestone.*

VI. *The Cincinnati Group.*

During the past season I have been able to make some modifications in this scheme, as far as the Potsdam, Lower Magnesian, and St. Peter's are concerned, for the region of south central Wisconsin, especially in Dane and Columbia Counties. The succession now made out is as follows, beginning below:

I.	The Lower or Potsdam Sandstone	800 feet.
II.	The Mendota Limestone	30 "
III.	The Madison Sandstone	35 "
IV.	The Main Body of Limestone	80–120 "
V.	The St. Peter's Sandstone	80–100 "
VI.	The Buff and Blue Limestones.	

I. *The Potsdam Sandstone.*—In the region of the "Four Lake Country," about Madison, in Dane County, only the upper layers of this great formation are to be seen. Farther north, in southern Columbia County, the northerly rise of the rocks brings lower layers to view. In all this region the upper 50–100 feet of the formation are decidedly dolomitic, but nevertheless are very different and easily distinguished from the overlying *Mendota limestone.* Borings from artesian wells at Madison and Janesville go to show that some dolomitic admixture continues in the sandstone to within 200 to 300 feet of the Archæan, which is entered by two borings at Madison. The lowest layers seem, however, to be a coarse quartzose, non-dolomitic material. The dolomitic admixture in the upper layers amounts to 15 or 20 per cent. In the Janesville well there was some indication of the existence of a distinct layer of limestone at a very considerable depth in the Potsdam. *Scolithi* are the only indications of life.

II. *The Mendota Limestone.*—This limestone has everywhere in the region around Madison, and in fact wherever recognized, very marked characters. It has always a peculiar yellowish, dirty appearance, and is frequently stained by reddish patches and seams of non-hydrated oxide of iron. Layers of green sand occur, especially about the junction with the underlying sandstone. This limestone is usually heavy-bedded below and thin-bedded to shaly above. It is always to some extent arenaceous. In localities it is fossiliferous, carrying trilobites especially, and most common among them the *Dikellocephalus Minnesotensis,* or some very similar form. The fossil locality at Mazomanie, on the west side of Dane County, which is alluded to by Hall

in his monograph on the Fauna of the Potsdam Sandstone,* is doubtless at the horizon of the Mendota limestone. The name *Mendota* is given from the exposures on Lake Mendota in Dane County, where the rock was first recognized as a separate stratum.

III. *The Madison Sandstone.*—This sandstone having been first recognized in the vicinity of the city of Madison, where it is largely used as a building stone, I have thought proper to give it this name provisionally. It is in its lower portions always, and in its upper most commonly, a very coarse quartzose sandstone, consisting of very much rolled grains of limpid quartz, without admixture of dolomitic material, or with only a very slight amount. Frequently the rock is an incoherent mass of white sand. In other cases there is an admixture, or cement, of hydrated oxide of iron, the rock having a brownish hue, the oxide staining the grains of limpid quartz superficially only. In some localities, again, the upper layers are decidedly dolomitic, and then the rock becomes a building stone of considerable value. This layer of sandstone has been recognized over a wide area south and east of the Wisconsin River. The dolomitic varieties contain from ten to twenty per cent of calcium and magnesium carbonates.

IV. *The Main Body of Limestone.*—This limestone is never more than 85 feet in thickness in the region around Madison. Farther north, in Columbia County, it reaches an extreme of 120 feet. It consists of three portions, not always well defined from one another, but still distinct. These are, beginning below: (1) thin, often irregular layers, carrying near the base persistent layers of green sand, and immediately at the junction with the Madison sandstone a very peculiar siliceous oolite layer, a few inches in thickness. This oolite consists of rounded granules $\frac{1}{64}''$ to $\frac{1}{32}''$ in diameter, closely packed in a pulverulent siliceous matrix, the whole having a milky white color. The smaller granules are seen under the microscope to be single grains of limpid quartz, the larger ones being aggregations of quartz grains. This layer is astonishingly persistent, having been seen everywhere where the base of this limestone is exposed, and at points many miles apart The whole thickness of this portion of the formation is about 20 feet. (2) Very heavily and indistinctly bedded light buff limestones, breaking with a conchoidal fracture and carrying considerable chert in nodules, in thickness about 20 feet; (3) the upper layers of the formation, in general consisting of (*a*) thin-bedded layers, (*b*) very heavily-bedded layers, carrying very numerous large chert concretions and continuous chert layers, and (*c*) concretionary

* 16th Annual Report, Regents of the University of the State of New York, on the condition of the State Cabinet of Natural History, Appendix D, 1863.

and brecciated layers. In none of these subdivisions have any fossils been seen.

V. *St. Peter's Sandstone.*—This formation appears with its usual characters, except that east of Madison it presents a very marked deviation from its usual very uniform thickness of 100 feet, being reduced as low as 40 feet.

On the Mississippi River bluffs, in the vicinity of Winona and La Crosse, and again farther south, there exists, so far as now known, between the Potsdam and St. Peter's sandstone, 200–250 feet of dolomite without sandstone layers. Farther northwest, there occurs in the valley of the Minnesota River—according to Professor N. H. Winchell, State geologist of Minnesota—the following succession of strata, beginning below:

I. The Lower or Potsdam Sandstone.
II. The St. Lawrence Limestone.
III. The Jordan Sandstone.....50 feet.
IV. The Shakopee Limestone .....70 "
V. The St. Peter's Sandstone.

His description of the characters of the Shakopee, Jordan, and St. Lawrence beds shows that these strata are respectively very strikingly like my Main Body of Limestone, Madison Sandstone, and Mendota Limestone. Future investigations may show that the Jordan and Madison sandstones are somewhere continuous, in which case Mr. Winchell's names would appropriately be extended to the Wisconsin strata. So far as now known, however, the two regions in which these similar alternations occur are separated by an area where all merge into a mass of limestone whose thickness is much greater than their combined thickness.

The following schedule serves to show the probable equivalence of the strata in these different regions:

<table>
<tr><th></th><th>South Central Wisconsin.</th><th>Mississippi Bluffs.</th><th>Minnesota River.</th></tr>
<tr><td rowspan="5">Canadian.</td><td>St. Peter's Sandstone.</td><td>St. Peter's Sandstone.</td><td>St. Peter's Sandstone.</td></tr>
<tr><td>Main Body of Limestone, 80 to 120 feet,</td><td rowspan="3">Lower Magnesian Limestone, 200 to 250 feet.</td><td>Shakopee Sandstone. 70 feet.</td></tr>
<tr><td>Madison Sandstone, 35 ft.</td><td>Jordan Sandstone, 50 ft.</td></tr>
<tr><td>Mendota Limestone. 30 feet.</td><td>St. Lawrence Limestone.</td></tr>
<tr><td rowspan="2">Primordial.</td><td>Lower or Potsdam Sandstone.</td><td>Lower or Potsdam Sandstone.</td><td rowspan="2">Lower or Potsdam Sandstone.</td></tr>
</table>

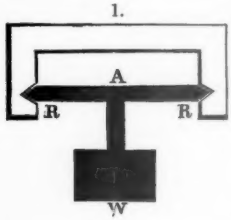
University of Wisconsin, February 13, 1875.

ART. XLVIII. — *On the application of the Horizontal Pendulum to the measurement of minute changes in the dimensions of Solid Bodies;* by O. N. ROOD, Professor of Physics in Columbia College.

[Read before the National Academy of Sciences, Nov. 4th, 1874.]

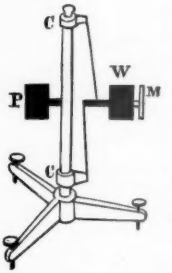
IN figure 1, let RR represent an inflexible rod of steel placed horizontally, and supported at its extremities by pivots on which it turns freely, and let W be a weight inflexibly attached to the rod as indicated. It is evident that WA when left to itself will assume a vertical position, and that the whole apparatus will constitute essentially an ordinary pendulum. If now an attractive or repulsive force be made to act on W, the pendulum will tend to be deflected from its vertical position, and if the force is sufficiently powerful a sensible deflection will be observed. In an arrangement of this kind, aside from friction, the opposing force to be overcome will of course be the attraction of gravitation; if, however, we gradually elevate the rod RR, the gravity component will diminish, and become zero when RR is vertical, and consequently AW horizontal. In his articles on the Horizontal Pendulum, Zöllner* has shown experimentally how this may be accomplished to an almost incredible extent, so that an apparatus of this general nature in his hands became capable of obeying even the feeble attractive force of the moon!

1.



I give here a diagram of Zöllner's horizontal pendulum; at W is the weight, the inflexible rod being replaced by fine steel wire or watch-spring, stretched as shown on the vertical column CC, the whole being supported by a tripod with leveling screws. P is a counterpoise; M a mirror for reflecting the divisions of a scale to a telescope. The height of this apparatus was about 30 inches; it was mounted on a pier like an astronomical instrument, and enclosed in a small building by itself, the observations being made from without.

2.



In the remarkable papers above referred to, Zöllner also pointed out the extreme sensitiveness of this apparatus to changes in level, and it at once occurred to me that by suitable modifications and additions, it could be converted into an instrument of unprecedented delicacy for studying minute changes in the dimensions of solid bodies.

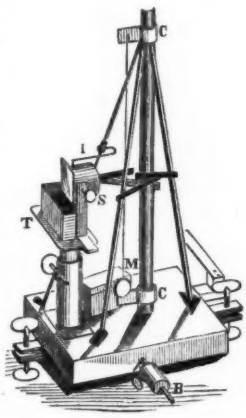
* Pogg. Ann. for 1873, cl, 131, 134.

Arrangement of a Horizontal Pendulum for measuring minute distances.

The apparatus constructed by me was almost entirely of brass; the dimensions were as follows: the height of the tubular column CC, fig. 3, was 350 mm.: distance *ab*, fig. 4, 5 mm.; distance *a*W, 58 mm.; weight of pendulum, 137 grams, nearly. The whole was supported on a well braced and firmly constructed wooden stand, which was hung by its upper end on the brick walls of the college-building, and again attached to them below, so as to prevent vibrations independent of the walls of the building itself.

An inspection of Zöllner's apparatus shows that its form was such as to render the column CC, fig. 1, quite liable to vibrations of its own; this I guarded against by the addition of three long and the same number of short cross-braces, as shown in fig. 3; they were found to make a most marked change for the better, and gave the instrument a stability which it previously did not possess.

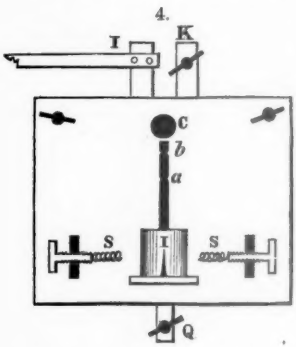
3.



Again, the German astronomer provided no means for bringing his instrument to rest, and in his published observations this actually never was the case, the extremes of the oscillations being employed for ascertaining the position of the pendulum. As this mode of taking readings was, in my case, owing to the locality and nature of the work, wholly out of the question, it became necessary to supply this defect. Very good results were obtained simply by attaching to the pendulum a wire bent in a series of zig-zags, and immersed in a box filled with olive-oil. By removing with the pliers successive portions of the wire, it was found that matters could be arranged so that the instrument came to rest after a couple of oscillations. The oil-box rested on a little table provided with rack-work to adjust its height and remove it when necessary; it is shown at T in fig. 3; its dimensions were as follows: length 70 mm., breadth 30 mm., depth 32 mm. The wire was placed of course as near the center of the box as possible, and the effects of capillarity were not sensible. The above arrangement is the one actually employed in making the experiments detailed below, but I have some reason to suspect that, owing to its viscosity, there was a tendency on the part of

the pendulum, *after it had once come to rest*, to obey impulses from without more tardily than was quite right. To obviate this possible difficulty I afterward provided the pendulum with a paddle instead of a wire, and caused the former to move loosely like a piston in the interior of a suitable box, which was entirely submerged in *kerosene* oil; the results were very promising, but I have not had time to use this method in an extended set of experiments.

At SS, figs. 3 and 4, are stops which confine the motion of the pendulum within narrow limits; they consist of spiral springs, which are fastened in the prolongation of adjusting screws. The springs form an essential part of this indispensable arrangement, and without their aid it was often found impossible to complete the leveling, so as to give the instrument even a moderate degree of sensitiveness.



At I, figs. 3 and 4, is shown an index or pointer, intended to facilitate the adjustment of the pendulum with regard to the scale, and readily bring it into the zero of position. It makes a very convenient addition, and is observed by a lens placed outside of the glass case enclosing the whole apparatus.

I may here remark, that the above-mentioned additions ought hereafter to be made to the horizontal pendulum, even when constructed solely for astronomical purposes, the oil-box being replaced by an air-box, contrived so as to reduce the tendency to oscillate. Compare Töpler, "Ueber einige Anwendungen der Luftreibung bei Messinstrumenten," Pogg. Ann., 1873, xlix, 416.

Mode of suspension.—In the first experiments fine iron wire was employed, but it was soon found that its presence rendered accurate magnetic observations impossible; and besides, although it was as fine as was consistent with safety, its torsion was noticeable. I afterward replaced it with narrow strips of elastic copper-foil, such as is used by jewelers, the ends being soldered to small thin plates of brass to prevent tearing, and these again connected with fine, hard-drawn brass wire. The copper-foil was adopted merely as a temporary expedient, but as it was found to answer well, and to be free from sensible torsion, it was retained. Experiments were made beforehand on its strength, and it was loaded up to within about two-thirds of its breaking strain.

At M, fig. 3, is a milled head for winding up the brass wire attached to the lower copper strip and thus bringing the pendulum into a horizontal position, i.e., its real object being to adjust the mirror of the pendulum with regard to the scale and telescope

Leveling screws.—These were made of brass with eighty threads to the English inch, the two rear screws being at a distance of only two inches apart. The front screw and one of the rear screws rested on plates of brass or glass, which were properly countersunk and cemented in a level position on the shelf. They were provided with the easily removable lever-arms 70 mm. long, and the leveling was always completed by giving gentle taps to these arms, with some light rod such as a lead-pencil.

Micrometer.—The left-hand rear screw, I, fig. 4, was used as a micrometer; it rested on a small leveled plate of glass and was provided with an arm 140 mm. in length, which was capable of moving over $\frac{1}{2}$ or $\frac{1}{3}$ of a degree of arc between two fixed points. To the extremity of the arm were attached two threads, one of which reached directly to the observer, while the other first passed over a small pulley; the threads were retained in a horizontal position by proper supports, and served to turn the micrometer-screw to and fro through some known fractional part of a degree. The distance traversed by the end of the lever-arm was measured with a compound microscope placed over its extremity; the length of this arm being known, and the number of threads of the screw, the actual upward motion could be calculated.

At B, fig. 3, is a counterpoise, its object being to remove most of the pressure from the micrometer screw.

Scale and Telescope.—A glass scale divided into millimeters was used; the telescope magnified about 60 diameters: the lines of the scale appeared to the observer, when referred to a distance of ten inches, to be about eight mm. apart, so that there was no difficulty in estimating tenths of a division.

Sources of error.—The main difficulties encountered in making the observations given below may be divided into two classes, viz: those due to accidental vibrations, and those dependent on changes of temperature. The apparatus, as may be imagined, was exceedingly sensitive to vibration, and the locality used by me, in this respect, one of the most unfavorable in this country; for, apart from carriages and street-cars, locomotives and trains of cars passed at a distance of 300 feet continuously during most of the day and the greater part of the night. Hence, in spite of the oil-box, the pendulum was never completely at rest, except for three or four hours after midnight: during the day-time the vibrations were often so rapid

as to render the scale-divisions invisible. Still, in spite of these disturbing causes, an extended series of experiments has shown that the inherent stability of the apparatus is such that these external influences produce, during a moderate interval of time, little or no permanent change in the instrument, and their effects can consequently be eliminated by making a sufficient number of observations. To illustrate the delicacy of the apparatus, I may remark that children playing on an iron bridge, 360 distant, caused temporary deflections of one or two divisions, and that similar deviations were caused by the lower notes of an organ in a neighboring church, the medium and higher tones producing no sensible effect. It was found, however, necessary to guard more sedulously against disturbances originating in the building itself, as they were more apt to produce permanent effects; this evil, however, practically only subjected the observer to temporary interruption.

Changes of temperature produce two different kinds of effect on the apparatus; in the first class we may place those which would be compensated by turning the leveling screw Q, fig. 4; in the second, those that would be neutralized by turning either of the other leveling screws. It is evident that changes of the first class alter the sensitiveness of the apparatus or the value of a scale-division, but on account of the comparatively large distance between IK and Q, these effects are small, and may be rendered almost insensible by attention to constancy of temperature: thus far they have not proved a source of annoyance.

The case is different with the second class; the leveling screws I and K being separated only by a distance of 50 mm., it is necessary, on their account mainly, to preserve the temperature of the apparatus as constant as possible. The means of accomplishing this I shall consider in the second part of this article, taking up in the present the method of eliminating errors that are introduced from this source. It is evident that changes of the kind now under consideration will communicate to the pendulum a continuous motion toward the right or left, and will finally drive it to the stops, and that all the readings will be affected with a constant or changing error. If the motion is so slow that the operation of reaching the stops consumes an hour or even less, it is not a source of serious inconvenience, and the errors thus introduced can easily be eliminated.

General mode of experimenting.—In all cases the micrometer screw rests directly or indirectly on the body the change in whose dimensions is the subject of study, and the first proceeding will naturally be to ascertain whether the different portions of the apparatus are at rest relatively to each other, or approximately so. Afterward the value of a scale-division can

be obtained by repeatedly moving the arm attached to the micrometer screw, by the aid of the threads which reach to the observer seated at the telescope. When this has been satisfactorily accomplished, the body to be experimented on is subjected to the desired influence, and the change in its dimensions noted; for example, the change in the longitudinal dimensions of a bar of iron when magnetized produces with this instrument a large sudden deviation, and it is also possible to note the gradual increase in its dimensions, owing to the heat developed by the act of demagnetization, and I am at present engaged in studying with it the effect of magnetization on the *lateral* dimensions of iron bars; in short, the instrument as now arranged is applicable to the solution of a great number of delicate problems.

Mode of making and calculating the observations.—The best way of observing, whenever possible, is to make a continuous connected series of readings, so that the second reading is equally related to the first and third, the third equally to the second and fourth, etc. When this proceeding is used it is possible to obtain correct results, even though the pendulum have an independent motion of its own. To take a simple example, let us suppose that the object required is to determine the value of a scale-division, and that by the aid of the micrometer-screw a series of continuous readings have been obtained. We have then to consider four principal cases:

1*st*, *The pendulum had no independent motion of its own.*—In this case it is of course a matter of indifference what method is employed in working up the results; i.e., whether the readings are treated in independent pairs or as a continuous series.

2*nd*, *The pendulum has a uniform motion of its own.*—Call the actual readings A, B, A′, B′, A″, B″, etc.; let x = the true quantity, and let the motion be positive or tend to increase the readings; d = the distance passed over during the interval from one reading to the next following; let d be positive, and B, B′, B″, represent the larger readings. We then have for the readings:

$$\begin{aligned} A &= A \\ B &= A+x+d \\ A' &= A \quad +2d \\ B' &= A+x+3d \\ A'' &= A \quad +4d \end{aligned}$$

Then as the readings are continuous, subtracting the first from the second, the third from the second, the third from the fourth, the fifth from the fourth, etc., we obtain a set of differences alternately too large and too small, thus:

Differences.	M′.
B − A = $x+d$	
B − A′ = $x-d$	 x
B′ − A′ = $x+d$	
B′ − A″ = $x-d$	 x

The average of each pair of differences will give the true quantity, x, free from errors introduced by motion. In the case now under consideration the average of the column M′ will be equal to the average of the column differences, so that the final result will be identical whether we employ the average of one or the other, but by employing the column M′ we have before us the identical observations free from contaminations due to the independent motion of the pendulum, thus enabling the observer more readily to judge of the reliability of the observations, and to calculate their probable error.

2. *The distance passed over independently by the pendulum increases during each observation by a constant quantity.*—Retaining the same notation, etc., as before, we have:

	Readings.	
A	= A	= A
B	= A + $x+d$	= A + $x+d$
A′	= A + $d+2d$	= A + $3d$
B′	= A + $x+d+2d+3d$	= A + $x+6d$
A″	= A + $d+2d+3d+4d$	= A + $10d$
B″	= A + $x+d+2d+3d+4d+5d$	= A + $x+15d$

Taking, then, the differences according to the method above indicated, we have:

Differences.	M′.	M″.	M.
$x+d$			
$x-2d$	$x-\frac{d}{2}$	$x+\frac{d}{2}$	x
$x+3d$			
$x-4d$	$x-\frac{d}{2}$	$x+\frac{d}{2}$	x
$x+5d$			

The column marked M′ is obtained by taking the average of pairs of differences as indicated by the vinculums on their left-hand side; the column M″ by using those on the right; the final column M by combining in pairs the quantities under M′ and M″. It is evident that the final column of means, M, will in this case give the correct value, or x, and that the average of the column of differences will be incorrect by $-\frac{d}{2}$ if an even number of readings be used; and if an odd number be employed, by $+d$, $\frac{2}{3}d$, $\frac{3}{5}d$, $\frac{4}{7}d$, etc.

3. *The distance passed over independently by the pendulum during each observation increases by an increasing quantity.*—This case may perhaps be most quickly illustrated by a numerical example arranged algebraically, the changes introduced being far larger than ever would be met with in practice.

Let the true number, x, equal 30; the first reading equal 25; we then have:

	Readings.
25	$= 25$
$25 + 30 + 1$	$= 56$
$25 + 1 + (1 + 2)$	$= 29$
$25 + 30 + 4 + (3 + 3)$	$= 65$
$25 + 10 + (6 + 4)$	$= 45$
$25 + 30 + 20 + (10 + 5)$	$= 90$
$25 + 35 + (15 + 6)$	$= 81$
$25 + 30 + 56 + (21 + 7)$	$= 139$

Differences.	M′.	M″.	M.
31			
27	29·	31·5	30·25
36			
20	28·	32·5	30·25
45			
9	27·	33·5	30·25
58			

It is evident in this case, that even the final mean will be affected with a small constant error; still for practical purposes this difference from the correct quantity will be far below the unavoidable errors of observation.

As the method with three columns applies to an increasing rate, it is evident that it will apply equally well to one which diminishes, and it hence follows that if the motion decreases till it is zero, and then begins to increase, being affected with the opposite sign, its effects will still be eliminated by the proceeding above described.

I proceed now to give some examples to show the character of the results that can be expected from the horizontal pendulum under very unfavorable conditions, i. e., when exposed to vibration and changes of temperature. All the observations given below were made in the day-time, the quietest portions being selected when comparatively few locomotives and trains of cars were passing; no extraordinary precautions with regard to temperature were employed, the pendulum not being enclosed except in its glass case. All the observations are in the form of determinations of the value of a scale-division, a proceeding well calculated to illustrate the capabilities of the instrument. The first four constitute a coherent series, the same adjustment of apparatus being used in them all; the others are independent sets made with different adjustments, and intended to illustrate the effects of change of temperature, etc.

Determinations of the value of a scale division.

In No. 1, after using the micrometer-screw, five readings were taken consecutively, the interval between them being only that required for making the record; in Nos. 2 and 3 single readings only were taken, but each reading is to be regarded as a mental average of at least two or three readings; in No. 4 twenty-five consecutive readings were taken on each occasion. The best mode, on the whole, seems to be to take in each case not less than five or more than ten rapid readings, and then again to use the micrometer-screw.

No. 1.

Actual readings.					Average.	Difference.
54·2	53·2	53·			53·4	27·8
81·5	80·9	81·6	80·8		81·2	27·8
53·5	55·	53·4	53·	52·	53·4	29·2
83·	82·3	83·	83·	82·	82·6	29·0
56·3	54·2	54·	51·6	52·	53·6	28·1
82·	81·	83·	81·3	81·5	81·7	29·6
53·2	52·7	51·	53·5	50·2	52·1	29·4
80·3	81·3	82·8	82·	81·2	81·5	28·2

Although in these observations the temperature seems to have been constant, yet for the sake of uniformity I have preferred to treat them according to the method above described.

M′.	M″.	M.
27·8	28·5	28·15
29·1	28·5	28·80
28·8	29·5	29·15
	Final average,	28·7

The probable error is 0·198 of one scale division; which, with the adjustment then employed, corresponds to $\frac{1}{17,300,000}$ of an English inch.

No. 2.

Actual readings.	Diff.	M′.	M″.	M.
21·	29·	28·	28·25	28·12
50·	27·			
23·	29·5	29·5	30·25	29·87
52·5	29·5			
23·	31·	31·75	30·25	31·
54·	32·5			
21·5	28·	26·75	26·	26·37
49·5	25·5			
24·	26·5	27·	27·9	27·45
50·5	27·5			
23·	28·4	27·75	28·5	28·12
51·4	27·1			
24·3	29·9		Final average,	28·48
54·2				

The probable error is 0·461 of a scale division, which corresponds to $\frac{1}{7,460,000}$ of an English inch.

No. 3.

Actual readings.	Diff.	M′.	M″.	M.
68·	26·	29·	30·25	29·62
42·	32·			
74·	28·5	29·25	30·1	29·67
45·5	30·			
75·5	30·2	32·2	32·1	32·15
45·3	34·2			
79·5	30·	29·55	29·70	29·62
49·5	29·1			
78·6	30·3	29·15	26·9	28·02
48·3	28·			
76·3	25·8	28·8	30·9	29·85
50·5	31·8			
82·3	30·	30·1	28·85	29·47
52·3	30·2			
82·5	27·5		Final average,	29·77
55·				

The probable error is 0·31 of a scale division, corresponding to $\frac{1}{11,360,000}$ of an English inch. It is to be remarked that while these last readings were being taken three heavy trains passed.

No. 4.

Av. of 25 read.	Diff.	M′.	M″.	M.
75·04	29·54	29·45	29·27	29·36
45·50	29·37			
74·87	29·17	27·93	29·75	28·84
45·70	26·70			
72·40	32·80		Final average,	29·10
39·60				

The probable error is 0·16 of a scale division, corresponding to $\frac{1}{21,560,000}$ of an English inch.

Combination of results, 1, 2, 3 *and* 4.

It is evident that the weights of these results are quite different; accordingly after taking all things into consideration, I assigned to Nos. 2 and 3 single weights respectively, to No. 1 a double weight, and to No. 4 a three-fold weight. Under these conditions the average of the four sets of observations is 28·99, with a probable error of $\frac{1}{16}$ of a scale division, corresponding to $\frac{1}{30,240,000}$ of an English inch.

In Nos. 1, 2, and in the first four readings of No. 4, there is no decided evidence that the pendulum had any independent motion of its own; in No. 3, its independent motion seems to have been nearly uniform.

I give now a case where the pendulum was affected with a rapid uniform motion: each reading given below is the average of ten rapid readings.

No. 5.

Readings.	Diff.	M′.	M″.	M.
101·5	23·1			
78·4	43·7	33·4	32·3	32·8
122·1	21·0			
101·1	41·4	31·2	31·76	31·48
142·5	22·12		Final average,	32·14
120·38				

The probable error is 0·44 of a scale division, corresponding to $\frac{1}{0,0\,5\,0,0\,0\,0}$ of an English inch.

No. 6.

Here each reading is the average of twenty-five rapid readings: the sign of the motion changed during the observations.

Readings.	Diff.	M′.	M″.	M.
92·5	53·36			
39·14	44·26	48·81	47·82	48·31
83·40	51·38			
32·02	48·07	49·72	46·13	47·92
80·09	44·19			
35·90	52·10	48·14	45·35	46·74
88·	38·60		Final average,	47·65
49·40				

The probable error is 0·31 of a scale division, corresponding to, $\frac{1}{0,0\,0\,7,5\,0\,0,0\,0\,0}$ of an English inch.

When it is recollected, that with the best optical and mechanical means, it has hitherto been hardly possible to measure quantities smaller than $\frac{1}{0,0\,0\,0,0\,0\,0}$ of an English inch, the field which the use of the horizontal pendulum, even under very unfavorable circumstances, opens, will be easily appreciated.

ART. XLIX.—*Contributions from the Sheffield Laboratory of Yale College* No. XXXIII.—*On Diabantite, a chlorite occurring in the trap of the Connecticut Valley;* by GEORGE W. HAWES.

IN my recent article upon the trap rocks of the Connecticut Valley,* it was shown, by means of analyses, that these rocks are of two kinds: 1st, the anhydrous dolerite; 2d, the chloritic dolerite, or diabase, which was formed from the same original melted mass as the dolerite by a process of hydration. The diabase is often amygdaloidal, and the cavities are filled with

* See this Journal, III, ix, 185, March, 1875.

various minerals, among which the most common are carbonate of lime, silica and chlorite; the two former substances being naturally produced in the change of the bisilicate, pyroxene, to the unisilicate, chlorite. At one point in the Farmington hills these amygdaloidal cavities are of very large size, often larger than an egg, and in them, with the quartz and calcite, there are large compact masses of chlorite, possessing a foliated and radiated structure and a dark green color. This association of minerals, which has often been recognized elsewhere, seemed to indicate that this was the chlorite which was distributed through the diabase, and an analysis was therefore made to determine to which member of the chlorite group it belonged.

A thin section of one of the masses under the microscope appeared to be perfectly homogeneous, and exhibited a very marked and beautiful dichroism. From a cavity in which the chlorite had thus been shown to be pure, the material was carefully selected for analysis. Its specific gravity was found to be 2·79; its hardness, 1; and its fusibility 3. The composition obtained was as follows:

	I.	II.	Mean.	Oxygen	
Silica,	33·23	33·25	33·24	17·73	17·73
Alumina,	11·13	11·02	11·07	5·16	5·83
Ferric oxide,	2·37	2·15	2·26	·67	
Ferrous oxide,	25·09	25·12	25·11	5·58	
Manganous oxide,	·40	·42	·41	·09	
Lime,	1·07	1·15	1·11	·32	12·66
Magnesia,	16·48	16·54	16·51	6·60	
Soda,	·25	·25	·25	·07	
Water,	9·89	9·93	9·91	8·81	8·81
	99·91	99·83	99·87		

This analysis gives for the oxygen ratio of the protoxides, sesquioxides, silica and water, 4.3 : 2 : 6 : 3, showing that it approaches very closely to a unisilicate in its composition. In order to ascertain whether this composition remains constant, the analysis was repeated upon another sample selected with like care from another cavity; the following were the results:

	I.	II.	Mean.	Oxygen.	
Silica,	33·65	33·70	33·68	17·96	17·96
Alumina,	10·93	10·75	10·84	5·05	5·90
Ferric oxide,	2·95	2·77	2·86	·85	
Ferrous oxide,	24·24	24·43	24·33	5·40	
Manganous oxide,	·38	·38	·38	·09	
Lime,	·72	·73	·73	·21	12·39
Magnesia,	16·56	16·48	16·52	6·61	
Soda,	·33	·33	·33	·08	
Water,	10·04	10·01	10·02	8·89	8·89
	99·80	99·58	99·69		

This analysis does not differ essentially from the preceding, and gives an oxygen ratio still nearer to 4 : 2 : 6 : 3. This ratio may therefore be taken as the correct one, making it a unisilicate of the pyrosclerite group with the formula:

$$(\tfrac{2}{3}\dot{R}^3 + \tfrac{1}{3}\ddot{A}l)^{\cdot}\breve{S}i^3 + 3\dot{H}.$$

Although agreeing with pyrosclerite in oxygen ratio, the much greater proportion of iron appears to authorize its recognition as a distinct species.

Dr. K. L. Th. Liebe, in his article on the diabase of the Voigtland and Frankenwald,* gives analyses of a chlorite of like occurrence which he carefully selected from specimens collected at several different points, and which he named *Diabantachronnyn*. Although his analyses differ somewhat from those here given, it is evident that the material he worked upon was very similar to the above, and like it in mode of occurrence and probably the same species. But since his long name, "diabantachronnyn," which was intended, as he says, to express the idea that the mineral is the coloring ingredient of the diabase, does not convey that meaning, the Greek of the latter part of the word not signifying *color*, and since the name is not in accordance with the principles of mineralogical nomenclature, I have taken the liberty of shortening it to *diabantite*, which though not expressing all that Liebe intended to convey, still indicates its relation to diabase.

Chlorites approaching this species in composition have been often analyzed with varying results and have received various names; but the great ease with which decomposition takes place upon such material under surface action makes it easy to derive from it a great number of intermediate products. The seams and cracks of both the diabase and dolerite of this region are often filled with a soft ferruginous chlorite, but which contains varying amounts of sesquioxide of iron, and is not homogeneous. A chlorite of the kind analyzed could hardly be expected to withstand the influence of percolating waters.†

The amygdaloidal cavities afford additional evidence to that already given, proving that the hydration of these rocks was produced by vapors that gained access to the molten mass during its ascent to the surface. For these cavities often contain bitumen, which in all probability was derived from the bituminous shales of the region, and was carried up along with the other products received from the strata and the subterranean streams encountered, and deposited in the cavities. This bitumen is widely distributed in the amygdaloidal trap, as was

* Jahrbuch für Mineralogie, 1870, p. 1.

† Kenngott has endeavored to prove that Liebe's mineral was common ripidolite; but these analyses show that it has a very different oxygen ratio.

long ago observed by Percival. The composition of the pyroxene* makes it easy to see how the change to chlorite took place under the action of these vapors. The thirteen per cent of lime was separated as carbonate, and the excess of silica was removed, while the small amount of alumina required, and which was not furnished by the pyroxene, was derived through the slight decomposition of the feldspar, which under the microscope appears to have lost its transparency.

ART. L.—*The Re-discovery of the Double Star*, H I. 41; by S. W. BURNHAM.

THE double star entered as No. 41 of Sir William Herschel's Class I. was apparently not found by Struve, as it is not included in his great catalogue, *Mensuræ Micrometricæ;* nor in any of the modern lists of double stars. I have not been able to find in the various works consulted any reference to it by any observer since Herschel's discovery nearly one hundred years ago. Sir John Herschel, in the catalogue of his father's double stars (*Memoirs of the R. A. S.*, xxxv), gives the approximate place for 1880 as follows:

$$\left.\begin{array}{l} \text{R. A.} = 17^{h}\ 40{\cdot}7^{m} \\ \text{Decl.} = +\ 73^{\circ}\ 0{\cdot}6' \end{array}\right\}$$

Nothing is said by Sir William Herschel of the magnitudes of the stars, or of the distance, further than that the pair belongs to his Class I. He made two measures of the position angle:

Aug. 29th, 1782, P = 350·0°
Mch. 7th, 1783, 354·3

A few weeks since this pair was searched for and readily found with a 6-inch refractor very near the place given above. It was identified as Lalande 32725, and its place from that catalogue, reduced to 1880, is:

$$\left.\begin{array}{l} \text{R. A.} = 17^{h}\ 42^{m}\ 16{\cdot}9^{s} \\ \text{Decl.} = +\ 72^{\circ}\ 59'\ 10'' \end{array}\right\}$$

I made three sets of measures of the angle, a mean of the result giving, P=340·2°. The components are of the 8th and 9th magnitudes, and separated about 1·2″, so that now it is not a difficult object even with a small aperture. A considerable diminution in the angle would seem to be beyond doubt, but further observations are necessary to determine positively whether or not this fine pair is a binary. It is about 46′ north of the well known double star, Ψ′ Draconis, and easily found without an equatorial mounting.

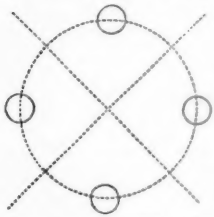
Chicago, May, 1875.

* This volume, March, p. 187.

ART. LI.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. 17.—*On the Distribution of Electrical Discharges from Circular Disks;* by C. J. BELL.

THE peculiar figures produced by the electrification of solid dielectrics have been studied by Lichtenberg; by W. V. Bezold (*Untersuchungen über elektrische Staubfiguren*, Pogg. Ann., cxl, 145, 1870); by Prof. Kundt, Pogg. Ann., cxxxvi, 612; by Theodore Karrass, Pogg. Ann., cxl, 160, 1870; and by H. Schneebeli, Archives des Sciences Phys. et Naturelles, xlvi, 269.

If a small circular disk is connected with the inner coating of a charged Leyden jar, and is suspended vertically over a glass plate coated with lycopodium, which rests upon a metallic plate connected with the outside coating of the jar, a number of points of disturbance will be seen on the glass beneath the rim of the circular disk, as in the accompanying figure.



The following investigation was undertaken to discover the law which regulates the number of points of greatest electrical disturbance shown by the small circles in the figure. The apparatus used was arranged as follows: the telescope of a cathetometer was removed, and an insulated arm substituted for it. To this arm was clamped in a vertical position a copper wire, at the lower end of which were attached the various circular disks used in the experiments. These disks were connected with one pole of a Ruhmkorf coil. Upon an insulated tripod below the disk was placed a plate of metal, from the bottom of which ran a wire to the other pole of the Ruhmkorf coil. The dielectrics, consisting of glass plates, 17 cm. square and 1 cm. thick, rested upon the plate of metal.

Six circular disks of different diameters were used, which were placed above the glass plate, at a constant distance from it. Six experiments were made with each plate. The results are contained in the following table:

Diameter of plates.	1	2	3	4	5	6	Calculated number.
41 mm.	14	14	13	14	14	14	----
34	12	12	11	10	12	12	11·6
29	10	9	10	10	9	10	10·
20·5	7	8	7	7	8	7	7·
15·5	6	5	5	6	6	5	5·
11·25	4	5	4	5	3	4	4·

The number of discharges was closely proportional to the diameter of the circular disks, or to their circumferences. The last column of the above table was calculated on this assumption. The area of the space on the glass affected was proportional to the area of the upper plate. Although the shape of the spots on the glass was not the same in all the experiments, yet the angle between them, subtended by their arc, was constant for the same plate. Much care and patience was necessary to produce the figures. The battery which was found to give the best results consisted of one Grove cell, the platinum of which was 14 cm. by 5 cm., and the zinc 30 by 7, with an internal resistance of ·25 of an ohm. The coil would give with this battery a spark of about 4 cm.

In order to obtain perfect figures the glass plate must be very clean, and perfectly dry. The best results were obtained when the plates were heated slightly. The lycopodium dust was sifted on the plate after the discharge, produced by lifting the breaker of the coil. If it is spread over the glass before the discharge, the figures lose their sharp outline. The glass plate must be 4 or 5 cm. larger than the lower plate of metal, otherwise a spark will pass around the edge from the terminals of the coil. The distance of the upper circular disks from the glass does not appear to have any effect upon the number of figures, but if they are placed at too great distance the figures are indistinct. The circular disks must be exactly parallel to the plate of glass.

ART. LII.—*Preliminary Note on an Examination of Gases from the Meteorite of February* 12, 1875; by ARTHUR W. WRIGHT.

BY the courtesy of President Thacher, of the State University of Iowa, the writer has received some fragments of this meteorite, an examination of which has yielded some very interesting results. The meteorite is of the stony kind, containing numerous small grains of metallic iron, and not greatly differing in appearance from others of its class.

A quantity of the iron, having been separated, was found to contain several times its volume of gaseous substances, much of which it yielded on a very moderate elevation of temperature. The spectroscope plainly indicated the predominance of carbon compounds, and an analysis showed that very nearly one half the gas was made up of the two oxides of that element, the approximate percentages being; CO_2, 35; CO, 14; the two together, 49 per cent. The residue consisted largely of hydrogen, but the exact proportion was not determined. These relations show a marked difference between the iron and

the stony meteorites as to their gaseous contents, as in the former the hydrogen is most abundant, while in the latter the oxides of carbon are the characteristic constituents.

The spectrum of the gases, at a few millimeters pressure, gave the carbon bands very brilliantly, the hydrogen lines being comparatively weak and inconspicuous, though at a very low pressure they became relatively stronger. The brightest carbon bands were the three in the green and blue, the red one being much feebler. Now these are precisely the ones most conspicuous in the spectra of some of the comets, and this fact is a remarkable confirmation of the received theory as to the meteoric character of these bodies. A more extended and particular account of the investigation will be given in the next number of this Journal.

Yale College, May 22, 1875.

ART. LIII. — *On Limonite with the Color and Translucency of Göthite;* by Prof. J. W. MALLET, Univ. of Virginia.

THE specimen which is the subject of this notice was received with other minerals from Capt. F. M. Imboden, of Richmond, Va., having come from the land of Dr. F. H. Griffin, near Big Lick, Roanoke Co., Va.

Passing through ordinary compact limonite there were veins of a quarter to half an inch in thickness, distinctly translucent on the edges of splinters, and having a deep blood-red color by transmitted light—by reflected light nearly black, with a luster between adamantine and resinous. Streak yellowish brown. Massive, with no traces of crystalline or fibrous structure. Hardness a little over 5. Sp. gr. = 3·76 at 15° C.

Analysis gave

Fe_2O_3	81·52	
Mn_2O_3	·11	
Al_2O_3	·26	
P_2O_5	2·38	
SiO_2	·51	
H_2O	14·95	= 99·73

The water was lost at the following rate with increasing temperature:

At 100° C. (for three hours),	1·70	p. c.
" 150° " "	·90	"
" 200° " "	3·60	"
" 250° " "	5·01	"
" Red heat	3·74	= 14·95 p. c.

If 2·68 p. c. of Fe_2O_3 be deducted as combined with the 2·38 of P_2O_5 to form ferric ortho-phosphate ($FePO_4$), and the

water lost at 100° (supposed hygroscopic) and the other minor constituents be neglected, we have left:

			Calc. for $Fe_4H_6O_9$ (limonite).
Fe_2O_3	78·84	85·61	85·56
H_2O	13·25	14·39	14·44
		100·	100·

The assumption of the P_2O_5 existing as a *hydrated* phosphate, with even as much water as in cacoxene or the basic salts described by Rammelsberg, will not suffice to bring the remaining ferric hydrate into accordance with the formula of göthite.

The mineral is obviously limonite in chemical composition, while the blood-red color has not, so far as I am aware, before been noticed in connection with this species, but has been looked upon as characteristic of göthite. How far the large amount of phosphorus present may have any relation to the peculiar appearance of the mineral may be questioned.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Composition of the so-called Hydrate of Chlorine.*—In many of the most recent text-books on Chemistry it is stated that the composition of the hydrate of chlorine, ordinarily given as $Cl_2+(H_2O)_{10}$, may also be written as $HOCl+HCl+(H_2O)_9$. The ground for this assumption is not entirely satisfactory; it seems to have arisen from a statement of Hiller, that the hydrate is formed when hydrochloric acid gas is passed into a solution of hypochlorous acid cooled to 0°. But since HCl and HOCl react upon each other to produce chlorine and water, the arrest of this action at 0° cannot be accepted as a fact in the absence of direct evidence. Görner has undertaken to decide between these formulas. Since, were the formula $Cl_2+(H_2O)_{10}$ correct, the sole product when the solution is agitated with mercury would be mercurous chloride; and were the formula $HOCl+HCl+(H_2O)_9$ the right one, that product must be mercuryl chloride, and finally, in presence of hydrochloric acid, mercuric oxide, the matter may readily be tested. Experiment proves the latter view to be in fact the true one; though by the subsequent action of the metallic mercury, some mercurous chloride was formed. In a lecture the above experiment may be useful in order to show that the reaction with water is the same as with potassium oxide or hydrate:

$$Cl_2+HOH=HCl+HOCl.$$
$$Cl_2+KOK=KCl+KOCl.$$

To this view Hugo Schiff, in a subsequent paper, decidedly objects, deeming the proof entirely insufficient. He gives quite a

number of facts to prove the contrary.—*Ber. Berl. Chem. Ges.*, viii, 287, 419, March, April, 1875. G. F. B.

2. *On the Constitution of Ammonium Compounds.*—The question of fixed or variable equivalence is yet a vexed one in Chemistry. V. MEYER and LECCO have made an investigation to ascertain whether nitrogen has in the ammonium compounds an equivalence of three or five. On the former hypothesis the constitution of ammonium chloride would be $N\equiv\!\!:\!\!\equiv H_3+H-\!\!-Cl$; on the latter it would be $H_4\equiv\!\!:\!\!\equiv N-\!\!-Cl$. The method by which the authors purposed to test the question was to submit to minute comparison the two di-methyl di-ethyl derivatives of ammonium, which may be thus formulated: $N\begin{cases}CH_3\\CH_3\\C_2H_5\end{cases}+C_2H_5Cl$, and $N\begin{cases}C_2H_5\\C_2H_5\\CH_3\end{cases}+CH_3Cl$. If nitrogen be a pentad, these two bodies must be identical; if a triad, they are only isomeric. The two chlorides were prepared with care, the one from dimethylamine, the other from diethylamine. They were then examined: 1st, as to their physical properties and those of their derivatives; 2d, their characteristic reactions in the wet way; 3d, their distillation products; 4th, the solubility of their platinum salts; 5th, the crystallographic identity of these platinum salts; and 6th, the fusibility of their picrates. In all these particulars they were found to be identical. The hypothesis that ammonium chloride is a molecular compound would seem, therefore, to be negatived, and the quinquivalence of nitrogen in all the ammonium derivatives established.—*Ber. Berl. Chem. Ges.*, viii, 233, March, 1875. G. F. B.

3. *On Methyl aldehyde and Methyl formate.*—Methyl aldehyde was prepared by Hofmann, the discoverer, by passing a mixture of air and the vapor of wood spirit over a red hot platinum coil. VOLHARD proposes a simple modification of this plan, as a lecture experiment, by which, in the course of an hour, sufficient of the aldehyde can be obtained to show its reducing power. A Davy's aphlogistic lamp—which consists of an ordinary spirit lamp upon and above the wick of which is placed a small platinum wire coil—is filled with methyl alcohol, lighted, and after a minute the flame blown out; the slow combustion which then takes place produces methyl aldehyde. It is only necessary to place over the wick an adapter connected at its smaller end with a Liebig's condenser, a receiver, one or two wash bottles, and an aspirator. The current of air is regulated so that the coil does not appear red in daylight, while yet it is sufficiently hot to prevent condensation in the adapter. If the aspiration be continuous, it is only necessary to keep the lamp filled in order to have the process continuous. The author collected in his experiments 90 to 100 grams of liquid in the receiver in twenty-four hours. By the warmth of the hand it reduced in a few minutes a solution of ammonio-silver nitrate and

gave a brilliant mirror. Saturated with hydrogen sulphide, it became a magma of crystals of methyl sulph-aldehyde. Estimated by its reducing power, however, the liquid contained but a little more than ·5 of one per cent. of aldehyde. The author subsequently prepared methyl formate, by distilling methyl alcohol recently saturated with hydrochloric gas, from calcium formate, in order to ascertain whether it would yield methyl aldehyde by the action of heat; a reaction analogous to that by which its chlorine derivative, methyl perchloroformate, yields carbonyl chloride. But the results were negative, the ether yielding methyl alcohol, carbonic oxide, carbonic acid, and marsh gas, the two latter in small proportion.—*Liebig's Annalen*, clxxvi, 128, Feb., 1875. G. F. B.

4. *Composition of Gum Tragacanth.*—GIRAUD has made a minute examination of the chemical characters of gum tragacanth. He finds (1) that this gum is but very slightly soluble in water, and that the product in the filtrate is not a definite principle, like arabin, but is a mixture of several substances; (2) that, digested on the water bath for twenty-four hours, with fifty times its weight of water, much of it is transformed into a soluble gum, which no longer swells after drying; this new substance is pectin; (3) that under the action of water containing one per cent of acid, the production of pectin takes place in two or three hours. It becomes entirely soluble, and alcohol precipitates pectin, not arabin, from the solution. Alkalies change it into pectates and metapectates. Hence gum tragacanth consists for the most part of a pectic principle insoluble in water, apparently identical with Fremy's pectose. From it, by precipitating the pectin solution by barium hydrate, and decomposing by an acid, pure pectin acid was obtained. Upon analysis, gum tragacanth yields as follows: water, twenty per cent; pectic compounds, sixty per cent; soluble gum, eight to ten per cent; cellulose, three per cent; starch, two to three per cent; mineral matter, three per cent; nitrogenous matters, traces.—*Moniteur Scientifique*, III, v, 361, April, 1875. G. F. B.

5. *On the Occurrence of Cane Sugar in Malted Grain.*—The question of the occurrence of dextrin and sugar in the cereals, whether malted or unmalted, is yet an open one. KUHNEMANN has sought to throw some light upon it by carefully examining malted barley for both these substances. Five kilograms of finely bruised malted barley was extracted cold with eight kilograms ninety-five per cent alcohol, the expressed liquid mixed with twice its weight of ether, and agitated with a little more than one-fourth its weight of water. The lower aqueous layer, treated with a little barium hydrate, was evaporated, filtered, and polarized. It rotated to the right, but contained two sugars, one reducing the copper test, the other not. Upon evaporation to dryness and extraction with alcohol, the two sugars were separated by fractional crystallization. In this way 0·6 of one per cent of crystallized sugar was obtained from the malt. When pure, this sugar is white, is sweet to the taste, crystallizes in well-

defined forms, and does not reduce the copper test. In its optical behavior, therefore, as well as in its physical and chemical properties, it appears to be identical with cane sugar. The malt-residue, extracted with water, yielded a solution from which alcohol precipitated a substance in white flocks, which is similar to, but is chemically not identical with, dextrin.—*Ber. Berl. Chem. Ges.*, viii, 202, March, 1875. G. F. B.

6. *Carbonyles, a new Class of Organic Bodies.*—M. BERTHELOT has recently instituted a new class of organic bodies, to which he has given the name of *carbonyles*, and to which he assigns three bodies hitherto rather ambiguous in chemical behavior. These are: allylene oxide (dimethylene carbonyle), $CO\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right)$ diphenylene-acetone (diphenylene carbonyle, $CO\left\{\begin{matrix}C_6H_4\\C_6H_4\end{matrix}\right)$ and ordinary camphor (terebutylene carbonyle, $CO\left\{\begin{matrix}C_5H_8\\C_4H_8\end{matrix}\right)$. Suberone, $C_7H_{12}O$, perhaps, belongs here also. The distinguishing feature of carbonyles is their double function. In the first place, they act like aldehydes, being able to fix hydrogen directly and to produce alcohols; while, like aldehydes, they are re-produced by the dehydrogenization of these alcohols. Again, like aldehydes, they may be formed by the direct or indirect oxidation of hydrocarbons; just as ethylene hydride and oxygen, $C_2H_4(H_2)+O$, produces ethyl aldehyde, $C_2H_4(O)$, so camphene hydride and oxygen, $C_{10}H_{16}(H_2)+O$, produces camphor, $C_{10}H_{16}(O)$, by indirect oxidation; and as ethylene by direct oxidation yields ethyl aldehyde, $C_2H_4+O=C_2H_4(O)$, so camphene, $C_{10}H_{16}+O$, gives camphor, $C_{10}H_{16}(O)$. But, secondly, it is to be observed that while aldehydes are produced by the indirect oxidation of saturated hydrocarbons, carbonyles result from the indirect oxidation of unsaturated hydrocarbons. This is a very material difference, since, beside its aldehydic function, the carbonyle molecule is unsaturated, and can unite directly with other unsaturated molecules. Hence, like carbonyl itself, from which these bodies take their name, they can fix directly the elements of water and form monobasic acids; as $CO+HOH=CHOH$, formic acid, so $CO\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right.+HOH=C_3H_6O_2$, propionic acid. So also, by reason of this unsaturation, they can unite directly with three atoms of oxygen to form dibasic acids; camphor, $C_{10}H_{16}O$, for example, forming with O_3, $C_{10}H_{16}O_4$, camphoric acid. So, conversely, the removal of water and carbon dioxide from a single molecule of a dibasic acid, yields a carbonyle, differing from the analogous production of acetones by the fact that the removal in the latter case is from two molecules of a monobasic acid. Regarding all hydrocarbons as derivatives of marsh gas, or formene, the formation of the three classes of aldehydes from them by indirect oxidation may be represented as follows:

Hydrocarbons. Aldehydes. Hydrocarbons.

$$\left.\begin{matrix} CH_4 \\ CH_2.CH_4 \\ C_2H_4.CH_4 \\ C_6H_4.CH_4 \end{matrix}\right\} \text{yield} \left\{\begin{matrix} CH_2O \\ CH_2.CH_2O \\ C_2H_4.CH_2O \\ C_6H_4.CH_2O \end{matrix}\right. \qquad \left.\begin{matrix} CH_2.CH_2.CH_4 \\ C_6H_4.CH_2.C_6H_4 \\ C_6H_4.CH_2.C_6H_6 \end{matrix}\right\} \text{yield}$$

Secondary aldehydes or acetones. Hydrocarbons. Carbonyles.

$$\left\{\begin{matrix} CH_2.CO.CH_4 \\ C_6H_4.CO.C_6H_4 \\ C_6H_4.CO.C_6H_6 \end{matrix}\right. \qquad \left.\begin{matrix} CH_2[-] \\ C_2H_4.CH_2[-] \\ C_6H_6.CH_2[-] \\ C_9H_{16}.CH_2[-] \\ C_{12}H_8.CH_2[-] \end{matrix}\right\} \text{yield} \left\{\begin{matrix} CO[-] \\ C_2H_4.CO[-] \\ C_6H_6.CO[-] \\ C_9H_{16}.CO[-] \\ C_{12}H_8.CO[-] \end{matrix}\right.$$

The author gives in conclusion the evidence that camphor itself belongs to this class of bodies, and says that had he not hesitated to found a new class of bodies on a single compound, he would long ago have proposed to consider camphor as a carbonyle.—*Bull. Soc. Ch.*, II, xxiii, 146, Feb., 1875. G. F. B.

7. *Formation of Hydroxylamine by the reduction of Dinitro-compounds.*—Whenever a nitro-organic derivative, in which but a single nitro-group is united to any one carbon atom, is reduced with tin and hydrochloric acid, the nitro-group, as is well known, becomes an amido group. V. Meyer and Locher have experimented to ascertain what would be the result on reduction if two such groups were so united. For this purpose they selected the dinitropropane $CH_3-C(NO_2)_2-CH_3$ recently discovered by them, and introduced it into dilute hydrochloric acid containing metallic tin. In a short time the nitro-body had disappeared, and the solution, after removal of the tin by hydrogen sulphide, afforded on evaporation pure hydroxylamine hydrochloride. The organic reduction-product was acetone, so that the reaction is as follows: $CH_3-C(NO_2)_2-CH_3+H_8=CH_3-CO-CH_3+(NH_3O)_2+H_2O$. Ethyl-nitrolic acid reacts similarly, yielding nearly the theoretic quantity. Nitroform, however, combines both reactions, yielding beside hydroxylamine, hydrogen cyanide, and ammonia.—*Ber. Berl. Chem. Ges.*, viii, 215, March, 1875.

G. F. B.

8. *Viscosity of Gases.*—Capt. A. von Obermayer has compared the previous determinations of this quantity, and states that of the two hypotheses from which the dynamical theory of gases start, the older gives the co-efficient of friction of gases proportional to the square root, the newer (Maxwell's) gives it proportional to the first power of the absolute temperature. From the retardation of vibrating disks by the friction of the air, Maxwell found experimentally the power 1, O. E. Mayer the power $\frac{3}{4}$; by experiments on capillary tubes O. E. Mayer found the power $\frac{3}{4}$, J. Puluj the power $\frac{2}{3}$ of the absolute temperature.

For the more certain determination of this ratio, experiments on currents through four capillaries of glass and one of brass were undertaken; and together with the temperature of the room those of boiling water, congealing paraffin, and a mixture of salt and

snow were employed. A first series of experiments, less accurate, were carried out, with the difference of pressure variable; a second, considerably more exact, with the difference constant. The results of the two series agree very well, and confirm those of Mayer's experiments in a perfectly satisfactory manner. For the co-efficient of friction μ at the temperature t there were found:

According to the first series, $\mu = \cdot0001706\ (1 + \cdot002735\ t)$.

According to the second series, $\mu = \cdot00016477\ (1 + \cdot002723\ t)$.

—*Roy. Acad. of Vienna*, Feb. 4th, 1875; *Phil. Mag.*, xlix, 332.

E. C. P.

9. *Specific Heat of Carbon, Boron and Silicon.*—Dr. H. F. Weber presented a paper on this subject at the fifty-sixth anniversary of the Royal Würtemberg Land and Forest Management Academy at Hohenheim. The law of Dulong and Petit, that the product of the specific heat by the atomic weight is constant, holds true for most of the solid elements. Carbon, boron and silicon, however, seem to deviate considerably from this law, and give different results in their various allotropic conditions. A comparison of the results of different observers shows that while they differ very greatly from one another, the larger the interval of temperature employed the greater the result.

Dr. Weber has accordingly made a series of measurements at temperatures from $-80°$ to 1,000°. The amount of heat was determined by Bunsen's ice calorimeter, and the temperature when below 300° by a thermometer; for higher temperatures the heat given out by a platinum bar in cooling served to determine the temperature by calculation.

The first experiments were on the specific heat of the diamond. The collections of the Universities of Berlin and Vienna were placed at his disposal. It was found that the specific heat increased with the temperature from ·07 at $-50°$ C, to ·23 at 100°, and ·46 at a red heat. A similar increase is found in the case of graphite, and leads to the following conclusions:—That from a red heat upward, the specific heat of carbon does not vary more than the specific heats of those elements which fulfil the law of Dulong and Petit, and at these high temperatures there seems to be no real difference in the specific heat of the graphitic and that of the diamond modification of carbon. All anomalies, therefore, disappear above 600° C., and carbon then obeys the above law. A comparison of the specific heats of graphite, of dense amorphous carbon and of porous carbon showed that they were identical within the temperature interval 0° to 225°. A unit weight of porous carbon, as far as possible free from water, evolves 4·16 heat-units when wetted with water.

In the case of boron two hundred small crystals were used, having a total weight of ·67 grams. The observations were extended from $-40°$ to $+230°$ and showed a similar increase to that of carbon. It is, therefore, very probable that at higher temperatures the specific heat attains a constant value of about ·50, and consequently the number 11, which is generally accepted as the

atomic weight of boron, is really the atomic weight; further that the atomic heat of boron is about 5·5, and that therefore at a red heat boron obeys the law of Dulong and Petit.

Small brilliant steel gray crystals of silicon, weighing 1·123 grams, were next employed. From these it was shown that silicon does not form an extraordinary exception to the law of Dulong and Petit; so soon as the temperature passes 200° it comes within the sphere of this law. The smallest relative weight of silicon (28) hitherto found in the molecule of any of the gaseous compounds of this element is in reality the atomic weight of silicon.—*Phil. Mag.*, xlix, 161, 276. E. C. P.

10. *Action of Electric Currents on Alloys.*—M. E. OBACH, at the suggestion of M. Wiedemann, has tested the conclusions of Gerardin on the electrolytic decomposition of alloys. A series of experiments were made from which he concludes that the passage of the galvanic current produces no electrolytic effect either in amalgams or in alloys. After being traversed by a current, the sodium amalgam decomposes water at both poles exactly as before. The action of the current modifies neither the hardness nor the malleability of the lead and tin alloys, nor the fluidity of the potassium sodium alloys. It introduces in the neighborhood of the electrodes no change exceeding the limits of possible error in the analyses.—*Bibl. Univ.*, ccvii, 229. E. C. P.

11. *New Property of Aluminum.*—M. E. DUCRETET observes that on inserting in a galvanic circuit a voltameter with two electrodes, one of aluminum, the other of platinum, different effects are obtained according to the direction of the current. When the aluminum receives the negative electricity the water is decomposed and the current traverses the circuit freely. But on reversing the current the decomposition ceases and scarcely any electricity is transmitted. An electric bell inserted in the circuit in the first case rang violently, and in the second case did not move. Replacing the bell by an iron wire, in the first case it was melted, and not even heated in the second. A galvanometer gave in one case a deflection of 22° and in the other of only 2°.

The effect is produced instantly; it is constant and durable whatever the number of inversions of the current. If other metals are used instead of platinum, they are deposited on the aluminum and interfere with the experiment This stoppage of the current is not produced by a plate of gold, silver, platinum, copper, zinc, magnesium, tin, lead, etc., replacing the aluminum. A partial effect is produced with iron, but the surface is soon altered, with the disengagement of a bad odor. As to the aluminum, its surface appears to be preserved by a slight layer of alumina which is formed immediately, and remains, in spite of the inversion of the current.

Many practical applications of this property suggest themselves. Two messages may be sent over a telegraph line at the same time in opposite directions by using two voltameters with the aluminum on opposite sides. All trouble from variable resistance is thus avoided.—*Journ. de Phys.*, iv, 84. E. C. P.

II. Geology and Natural History.

1. *The Surface Geology of Ohio;* by J. S. Newberry. 80 pp. 8vo. (From the Report of the Geological Survey of Ohio, vol. ii. Columbus, 1874.)—Dr. Newberry here presents in detail the many facts which he has observed connected with the Quaternary of Ohio and the adjoining States, and the conclusions to which his various observations have led him. The successive events of the Quaternary, which he gives in the opening part of the chapter, are briefly as follows:

(1.) The period of cold and the great glacier over New England and the region west, north of the Ohio, during which the land stood above its present level.

(2.) A period of lower level, milder climate, retreating glaciers, great freshwater lakes; and also of the deposit of the bowlder clay, which is usually thinly laminated in Ohio and contains no bowlders; also of extended forests over much of the region left bare by the retreat of the glacier from Ohio, Indiana and Illinois, and of the formation of peat beds, in which occur the remains of the Mastodon, Elephant, Castoroides, etc.

(3.) A further subsidence, making the Mississippi an arm of the sea, and putting that part of the continent including Southern Ohio under salt water; the time when deposits of sand and gravel were spread over the peat beds of Southern Ohio, lacustrine clays laid down in Northern Ohio, and the lœss along the Mississippi Valley; when icebergs floated southward across the great lake region from the Canadian highlands, carrying bowlders, gravel and earth; when portions of the highlands of Ohio were low islands and shallows, and sand and gravel were accumulated and assorted about them by the waves; when certain drainage lines were determined, as those along the valleys of the Wabash, Scioto, Muskingum and the Beaver.

(4.) A very gradual "retirement of the sea," with "intervals of rest and recession;" and, as a consequence, the formation of terraces along river valleys, "by the arrest of their flow and the deposition of the materials they transported in the dead water which partially filled these valleys;" the gradual draining of the lake-region, leaving old shore lines around the lakes with terraces or lake ridges in some parts of their circuit.

The eras of elevation, subsidence, and subsequent elevation, indicated in § 1, 2 and 3, and 4, are those which the writer has defined as the Glacial, Champlain or Fluvial, and Recent or Terrace periods.

No marine relics of the era of submergence (§ 3) are stated to occur over the region that is supposed to have been then under the sea, or in the deposits then made; that is, in the lœss along the Mississippi River, or the beds of Southern Ohio. In fact, the fossils found are those of the land or of fresh water, and have led others to regard the deposits as simply of river origin. Indeed,

this seems to be the opinion which Dr. Newberry presents in his chapter on the læss, pages 36–38.

Dr. Newberry follows the announcement of his conclusions by an account of his observations on the Drift deposits of Ohio, the old deserted and buried river channels of the State and elsewhere, the heights and positions of the lake ridges, and on other topics of interest. The more prominent lake ridges south of Lake Erie, as shown on a map, are: the "North ridge," nearest the lake, 99 to 105 feet in height above the lake; the "Center ridge," 148 to 162 feet; and the "South ridge," 200 to 205 feet. Others also are named: the "Coe ridge," which may be identical with the last, 180 to 200 feet; the "Sugar ridge," 165 to 167 feet; the "Chestnut ridge," 189 to 191 feet. How far the different levels of these lake-ridges are due to differences, existing before the elevation, in the level of the high-water flats along the lake-borders, and to the existence of other mud or sand flats under water at different levels, it is hardly possible to determine. In bays and lakes having shallow shore regions, such flats, various in level, are common; and after an elevation, they would exist as terrace plains and be of different heights because retaining their former differences of level.

In the remarks on the origin of the cold of the Glacial period, Dr. Newberry gives his objections to the theory of Lyell, and states, in the course of his remarks, that this theory is that advocated by Prof. Dana. He has not appreciated the paragraphs in the last edition of Prof. Dana's Geology (pp. 541 and 755), in which the cold climate is attributed, not simply to an elevation of high-latitude regions, but to the effect which such an elevation would have on the oceanic currents, and thereby on the distribution by these currents of heat and cold, as noticed in this volume on page 314.

Dr. Newberry has labored long and zealously among the Quaternary deposits of Ohio and the adjoining States, and his chapter on the subject is one that may be studied with great profit. J. D. D.

2. *Prototaxites of Dr. Dawson, a genus related to the Taxineæ.*—Dr. Dawson's view that the *Prototaxites Logani* of the Devonian of Gaspé, cannot be regarded as a sea-weed, a surged by Carruthers, appears to be sufficiently sustained—independently of the argument from the structure—by the following facts which Dawson has published respecting the condition and general character of the fossil.* He says (in a paper in the "Monthly Microscopical Journal" for August, 1873) that "the mode of occurrence is sufficient" to convince any practical palæontologist that the plant cannot be a sea-weed. Its large dimensions, one specimen found at Gaspé Bay being three feet in diameter; its sending forth strong lateral branches, and gnarled roots; its occurrence with land plants in beds where there are no marine organisms, and which must have been deposited in water too shallow to render

*For a figure, see Dana's Manual of Geology, 1874, page 258.

possible the existence of the large oceanic Algæ to which Mr. Carruthers likens the plant—these are all conditions requiring us to suppose that the plant grew on the land. Further, the trunks are preserved in sandstone, retaining their rotundity of form even when prostrate; and are thoroughly penetrated with silica except the thin coaly bark. Not only are Algæ incapable of occurring in this way, but even the less dense and durable plants, as Sigillariæ and Lepidodendra are never found thus preserved. Only the extremely durable trunks of coniferous trees are capable of preservation under such circumstances. In the very beds in which these occur, *Lepidodendra*, tree ferns and *Psilophyton*, are flattened into mere coaly films. This absolutely proves to any one having experience in the mode of occurrence of fossil plants, that here we have to deal with a strong and durable woody plant."

The paper discusses also the microscopic structure of the fossil, and its probable affinities.

3. *Fossil Vertebrates of Cretaceous and Tertiary affinities in the same beds on the Saskatchewan.*—Prof. Cope has examined fossils collected by G. M. Dawson in beds of the "Fort Union Group," from a horizon 100 to 200 feet above the beds of Cretaceous No. 5. They include among Dinosaurs, *Cionidon stenopsis* Cope (about the size of *C. arctatus* Cope) and a species related to *Hadrosaurus*. But with these species of Cretaceous affinity there are two tortoises of the genus *Plastomenus* Cope (*P. coalescens* and *P. costatus* Cope), a genus of the Eocene, and scales of gars, closely resembling those of the genus *Clastes* of the Lower Eocene of the Rocky Mountains. "The list of species," says Cope, "short as it is, indicates the future discovery of a complete transition from Cretaceous to Eocene life more clearly than any yet obtained in the West" (or Rocky Mountain region).—*Proc. Acad. Nat. Sci. Philad.*, 1875, 9.

4. *Systematic Catalogue of Vertebrata of the Eocene of New Mexico, collected in* 1874. E. D. Cope, A.M., Paleontologist. 38 pp. 8vo. Washington, 1875. Geographical explorations and surveys under Lieut. Wheeler, of the Engineer Department, U. S. A. —Contains descriptions of some new genera and many species of Mammals, with some species of Reptiles, and embraces many details of importance.

5. *Daubrée on the Platiniferous rocks of the Urals.*—At a session of the French Academy of Sciences in March, Daubrée described the rocks of the Ural affording platinum. They have a base of chrysolite. The masses come from the conglomerates near Nischne Tagilsk, where platinum is obtained. Besides chrysolite, serpentine and chromic iron are intimately associated with the platinum. The facts seem to prove that the original platinum-bearing rock was a chrysolite rock more or less transformed into serpentine, and was accompanied with diallage, which is common in the specimens. The presence of chromic iron is also to be noted; for it appears to bear evidence as to the changes through which the gangue rock of the platinum had passed.

6. *The Geological Story briefly told, an Introduction to Geology for the General Reader and for beginners in the Science;* by JAMES D. DANA. 264 pages, 12mo, with numerous illustrations. New York & Chicago. 1875. (Ivison, Blakeman, Taylor & Co.) Price $1.50.—This work, although small, and different in arrangement from the author's Geological Manual and Text-book, gives the reader full illustrations of the principles of the science, of the methods of geological work, and of the course of geological history. It is simple in its language and full in its illustrations. After a few pages on the constituents, kinds, and structure of rocks, it takes up, in Part II, the subject of Causes in Geology and their Effects. Under this head it explains, *first*, the *making of rocks* (including the preparing of the material) through the agency of plants and animals, through the quiet work of air and moisture, through the work of the winds, fresh waters, ocean, and ice, and through heat,—the last topic including the effects of contraction and expansion, the formation of volcanic and other igneous rocks, and the subjects of solidification, metamorphism, and mineral veins. Then, *secondly*, it treats of the making of valleys and all depressions on the earth's surface; and, *thirdly*, of the making and shaping of hills and mountains, (1) by igneous ejections, (2) by the erosion of elevated lands, and (3) by the upturning and flexures of rocks, and bending of the earth's crust.

Part III, occupying 150 pages, takes up Historical Geology, describing the rocks that were forming, the most prominent kinds of plants and animals that were living, the mountains that were making, and other events, during each of the successive ages in the course of geological time; and ends with a brief review of the progress of life.

This volume is handsomely printed, and contains several cuts not in the Manual of Geology.

7. *Catalogue of Lower Silurian Fossils of the Cincinnati Group, found within* 40 *or* 50 *miles of Cincinnati, with descriptions of some new species of Corals and Polyzoa;* by U. P. JAMES, Cincinnati. New edition, much enlarged, 8 pp. large 8vo. Cincinnati, April, 1875.—The new species described by Mr. James are *Chætetes calycula, C. clavacoideus, C. Cincinnatiensis, C. (?) O'Nealli, Alveolites (?) granulosa, Ceramopora Nicholsoni, Ptilodictya acuminata* and *Alecto nexilis.*

8. *Origin of the Lower Silurian Limonites of York and Adams Counties, Pennsylvania;* by PERSIFOR FRAZER, Jr.—(Proc. Amer. Phil. Soc., March, 1875.)—Mr. Frazer, after describing the limonite deposits, attributes the origin of the ore to the presence of pyrites in the slates. The beds usually lie between the slate and Lower Silurian limestone, but the latter is generally little, if at all, acted upon or eroded, and often is not even stained.

9. BENTHAM, *Revision of the Sub-order Mimoseæ.*—This paper forms the third part of the 30th volume of the *Transactions of the Linnean Society*, fills over 300 quarto pages of letterpress, and is illustrated by five plates, exhibiting the principal varieties

in the legumes of *Mimoseæ*. The group, which now numbers 1200 species, under 29 genera, was first put into good order by Mr. Bentham about 30 years ago; and he has now taken occasion to revise it completely, while studying the South American species for the *Flora Brasiliensis*, after having re-examined the Australian ones for his *Flora Australica*. The generic characters, founded mainly on the stamens, of which he made happy use in the former monograph, have stood the test, as being the best as well as the readiest; and his facile arrangement has approved itself to other botanists (with one exception) as well as to his own enlarged experience. He has now brought in a new subsidiary character, that of the presence or absence of albumen in the seeds. This, for instance, is present in *Mimoseæ* but not in the *Acacieæ* and *Ingeæ*, i. e., the tribes with indefinite stamens. As to genera, the adage "by their fruits ye shall know them," however true it may be elsewhere, has little application here. This is illustrated by the figures of the pods of various *Mimoseæ* and *Acacieæ* subjoined to the memoir, and is shown in the letterpress by a general discussion of the facts. As to geographical distribution, it is interesting to note that Mr. Bentham reduces the number of species really common to the New and to the Old World, without any evidence or reasonable suspicion of recent transportation, to four species. *Entada scandens*, with its huge pods and hard seeds, not rarely wafted across the Atlantic by the Gulf Stream, is one; if of African origin, the trade-wind current may have given it to the West Indies. *Neptunia oleracea* is a tropical aquatic, conjecturally of South American origin, the seeds of which may have traversed the Atlantic; *Mimosa asperata*, probably also American, is not quite so readily accounted for in Africa; and the fourth, *Acacia Farnesiana*, is still more puzzling; but it would seem somehow to have found its way from Western South America to Australia and the Indian Archipelago before the days of Columbus; yet in all four cases, the want of differentiation is thought to indicate a comparatively modern dispersion. Of distinct but closely representative species in the two hemispheres, Mr. Bentham enumerates nine pairs. He might have added the case of two insular species, *Acacia heterophylla* of Mauritius, and *A. Koa* of the Sandwich Islands, only that he doubts if the two are sufficiently distinct. Seventeen of the 29 genera are restricted to one of the two hemispheres; but nine of these have only from one to three species, and but two (*Albizzia* in the Old World and *Inga* in the New) are at all numerous in species. Upon the more speculative discussion of the geographical data in reference to probable derivation, we cannot here enter. The subject is treated after the manner adopted in the memoir on *Cassia* and that on *Compositæ*. Remarking the great American predominance of the order in all its tribes, the author acutely remarks that "this high degree of recent luxuriance and prosperity of American races, however, can by no means be relied upon as evidence as to local origin, or even as to comparative remoteness of antiquity; for that may rather

be sought for where there are the greatest number of highly differentiated monotypes or oligotypes of limited areas and fixed characters, exhibiting the last remains, as it were, of expiring races; and these are undoubtedly to be met with chiefly in the Old World—in the first place in East Africa and the Mascarene Islands, and secondly in the Malayan Archipelago." But the search for original birth-places, as he intimates, leads only through hazardous conjectures into thick obscurity. Our notice is confined to the few prefatory pages, on account of their general interest. As to the monograph itself, it is a model, in form and substance. The nominative specific characters make a most favorable presentation of that mode. Still, where condensation is important, the single sentence and the prevalent ablative case have some advantage in terseness. A. G.

10. *Flora of British India*, by J. D. Hooker, C.B., etc., *assisted by various botanists.* Vol. I, pp. 740, 8vo. Reeve & Co., London. 1872–1875.—The third part, issued at the close of the past winter, brings this important work up to the close of the first volume, and nearly up to the *Leguminosæ.* This present part, which begins with *Geraniaceæ* and *Rutaceæ*, from the editor's own hands, is otherwise mainly the work of three or four English collaborators who have been enlisted in it, Messrs. Bennett, Hiern, and Lawson, and also Dr. Masters, the latter a botanist of no little experience. The younger botanists at all capable of this kind of work are few; accessions to the number are heartily to be welcomed. By their aid, under Dr. Hooker's efficient supervision, we may hope that this great undertaking will be duly carried through. A. G.

11. Miers, *On the Lecythidaceæ.*—A splendid memoir, of 64 pages and 33 plates, large quarto, forming the second part of the 30th volume of the *Transactions of the Linnean Society*, 1874, a wonderful piece of work for a man of Mr. Miers' great age. He proposes to restore the *Lecythideæ* or *Lecythidaceæ* as an independent order. The plates illustrate the floral structure of the twelve genera which the author recognizes, and the fruits of most of them. It is a remarkably interesting group, consisting of huge trees, all tropical American, with singular flowers and large woody fruits, a sort of pyxis, containing numerous nut-like seeds, of which Brazil-nuts (from *Bertholletia excelsa*) and Sapucaia-nuts (from a species of *Lecythis*) are well-known examples. Few botanists have had the opportunity of properly studying these noble plants, and no one has devoted to them so much attention as the veteran Miers. A. G.

12. *Synopsis Filicum.*—The second edition of the *Synopsis of all known Ferns*, by Hooker and Baker (London: Robert Hardwicke), issued near the end of the year 1874, has just reached us. It bears Sir Wm. Hooker's honored name, for the work was planned by him, as an abridgement of the *Species Filicum*, and the first sheets had passed through the press before his death; but most of the volume was prepared by Mr. Baker, from

mere notes and indications by his predecessor and from his own studies of the rich materials which were ready to his hand. Accordingly, in any particular reference to the contents, after p. 48, Mr. Baker's name would be used. The original edition was issued, in successive parts, between 1865 and 1868. A new one has long been wanted, and still is so, in a certain sense. For, although the editor has "endeavored in this edition to briefly characterize and fit into their places the new discoveries and the plants found upon fuller information to have been inadequately dealt with in the first," he has not been able to deal with them quite freely. The pages are in stereotype, so that the body of the old work has been reprinted—no doubt with corrections as far as might be—and the additions are collected in an appendix of 75 pages, followed by a good new index to the whole. This must serve for the present, and fern-students will be very thankful for the new help. But we hope that Mr. Baker, in due time, will re-elaborate the order completely. A. G.

13. GRISEBACH, *Plantæ Lorentzianæ.*—An elaborate paper, of 213 pages and two plates, 4to, separately issued from the 19th volume of Transactions of the Royal Society of Sciences of Göttingen, 1874. It describes a good collection of plants of the Argentine Republic made by Prof. Lorentz of Cordoba. It is prefaced by a brief account of the region, followed by some remarks upon the more interesting plants of the collection, under their natural orders. Many new species are proposed and a few new genera. Under *Hydroleaceæ*, a name adopted instead of *Hydrophyllaceæ* (we know not why), a new *Nama* and a new *Phacelia* are described; also a new "genus, valde anomalum," *Sterrhymenia*, which is appended to the order, along with *Cardiopteris!* The suggested relationship is not apparent. A. G.

14. *Botanical Contributions* contained in the *Proceedings of the American Academy of Arts and Sciences*, vol. x, 1875.—This volume, just about to be issued, contains the papers communicated to the Academy and accepted for publication during the year ending in May. The botanical papers are,—

Conspectus of the North American Hydrophyllaceæ; by ASA GRAY. pp. 312–332. As this paper consists wholly of descriptive matter, some general considerations respecting the order, its distribution, affinities, &c., may hereafter be given in this Journal.

Revision of the Genus Ceanothus, and Descriptions of New Plants, with a Synopsis of the Western Species of Silene; by SERENO WATSON. pp. 333–350. The species of *Ceanothus*, mainly Californian, had become difficult of determination. They are here cleared up and arranged, under 28 species, two or three of which are still obscure or uncertain, and disposed under two groups (*Euceanothus* and *Cerastes*), which are well marked, but hardly worthy of subgeneric rank and substantive names.—The miscellaneous new species described are 32 in number, all western, but the first is a low *Clematis*, which belongs as far east as Kansas. Among them are eleven species of *Silene*, of Oregon and Califor-

nia, the determination of which led to a study of all our western Silenes. The results are briefly recorded in a foot-note, giving the diagnoses of 21 species. At this rate we may rival Europe.

List of the Marine Algæ of the United States, with notes of New and Imperfectly Known Species; by W. G. FARLOW. pp. 351–280. The preceding papers bear the date of publication (April, 1875) as well as that of presentation, which it is well to know. It is omitted in Professor Farlow's neat and useful paper; but copies had reached us before the 1st of May. The species of the list being continuously numbered, we perceive that they amount to 430, of which 54 are additions to Dr. Harvey's Nereis (1857), and three or four are new. The notes are numerous and critical. We understand that Professor Farlow intends to follow up this paper with other publications upon our *Algæ*. A. G.

15. DANIEL HANBURY.—Not long ago we called attention to a most valuable book, the *Pharmacographia or History of Drugs*, by Prof. Flückiger of Strasburg and Daniel Hanbury of London, the first-fruits of much investigation, the precursor, as was hoped, of more extended similar works by the English author. We have now sadly to record the decease of Mr. Hanbury, of enteric typhoid, on the 24th of March, at his residence on Clapham Common, in the 50th year of his age. The obituary and biographical notices which have appeared in the London scientific journals, and in the Proceedings of the learned Societies, as well as loving individual tributes to an endeared memory, have given expression to the loss which has been sustained, and delineated the outlines of a most worthy and winning character. The loss is deplored, personally and scientifically, over wider circles and on this side of the Atlantic. The pupil and friend of Pareira and his successor in his line of work, an adept in pharmaceutical knowledge, a keen botanist, and a most assiduous and conscientious investigator, a man of simple and pure tastes, and happily of sufficient means, he had just withdrawn wholly from business in the noted house in which he had an inherited share, so that he might devote his powers and acquisitions without distraction to the natural history of drugs and useful vegetable products. He had already done much: more than sixty articles were contributed by him to a single journal, the editor of which declares that "the quality of what he did was almost faultless," that "he never wrote without having original information to impart, and his papers uniformly bear evidence of careful investigation and thorough knowledge." The Transactions and Journal of the Linnean Society (of which he was repeatedly a Councillor and the Treasurer at the time of his death) contain several of his papers. His first published paper, "On Turnsole," appeared in 1850; his latest, on the "Countess Chinchon and the Cinchona genus," appeared, since his death, in "The Academy" of the third of April. An ardent botanist and lover of plants, he travelled much in the south of Europe, accompanied Dr. Hooker in his explorations of Lebanon, and took an active interest especially

in the introduction of officinal plants and in ornamental cultivation. With one villa-garden on the shores of the Mediterranean—that of his brother at Mortola—his memory to us is indelibly associated. Although remarkably self-reliant, Mr. Hanbury was the opposite of self-asserting or ambitious; but his sterling worth was soon recognized by the principal learned societies and associations. He was early chosen into the Royal Society and served upon its Council in 1873. Born and educated in the Society of Friends, he remained a devout and attached member of it, while the graces and goodness of his character endeared him to all who knew him. With the sense of personal loss his scientific comrades mingle deep regrets that a career of unusual usefulness and promise is cut short, and that in a line in which, it is to be feared, he leaves no successor. *Hanburia Mexicana*, a striking Cucurbitaceous genus, commemorates his services to Botany. A. G.

16. *The Crustaceans of the Caves of Kentucky and Indiana;* by S. I. SMITH.—Through the courtesy of Dr. Packard of Salem, Mass., I have recently been enabled to examine the types of his *Crangonyx vitreus* from near Orleans, Ind., and also several specimens of an amphipod collected in Mammoth Cave by himself. All the specimens from Mammoth Cave are of a single species, which, there can be little doubt, is really the *Stygobromus vitreus* unintelligibly described from the same locality by Professor Cope. The species is really a *Crangonyx* and it should stand as *C. vitreus*, although very different from the one from Indiana which is referred to Cope's species by Dr. Packard and by him called *C. vitreus*. It is a small species, the largest specimen being less than a fourth of an inch (5·2 mm.) long, apparently wholly eyeless, and remarkable for the rudimentary character of the unibranched posterior caudal stylets, which are shorter than the telson. It seems to be near the typical species described by Bate, and it is closely allied in some respects to *C. tenuis*, also an apparently eyeless species, which I have described from wells at Middletown, Conn. Since this note was first written, I have examined several specimens of this last species, collected by Mr. J. K. Thacher, under stones in a small brook, near New Haven. From this it seems not at all improbable that the allied species from Kentucky and Indiana—and very likely also the eyeless, cave species of other groups—may still be found in the surface streams of the same region.

The specimens of Dr. Packard's species from Indiana are badly preserved but are sufficient to show that the species is very closely allied to *Crangonyx gracilis*, from Michigan, Lake Superior, etc., differing principally in the structure of the eyes, which are well developed and abundantly supplied with black pigment in *C. gracilis*, while in Dr. Packard's specimens they are observable with difficulty, are wholly without black pigment, are undoubtedly colorless in life, and are probably only imperfect organs of vision, although the structure of the facets can be distinctly made out.

The other differences are all very slight, scarcely sufficient to distinguish the subterranean form as a species, and certainly so slight that they would almost surely be overlooked if the two forms were found together.

As the crustaceans have recently been several times referred to as indicating the partially marine origin of the cave fauna of the Western States, a word in regard to their affinities may not be out of place. The species already described from Indiana and Kentucky are the following: *Cambarus Bartonii* Erichson, Mammoth Cave; *C. pellucidus* Erichson, caves in Ky. and Ind.; *Crangonyx vitreus* Smith, Mammoth Cave; *C. Packardii* Smith, wells, Ind.; *Cœcidotea stygia* Packard, caves and wells, Ind., and Mammoth Cave; *Euphiloscia Elrodii* Packard, caves, Ind.; *Cauloxenus stygius* Cope, caves, Ind. The genus *Cambarus* is strictly confined to American fresh waters, and *C. Bartonii* is one of the commonest species in the streams of the Western States. *Crangonyx*, as far as known, is wholly confined to fresh water. *Cœcidotea*, as far as we can judge from description and figures, is scarcely distinguishable, except in wanting eyes, from *Asellus*, a characteristically fresh water genus. The *Euphiloscia* was found also outside the caves and is allied to other terrestrial genera. The *Cauloxenus*, a Lernæan parasite of the blind fish, is so poorly described and figured, and the genera of the whole group to which it belongs are so difficult and imperfectly known, that it is useless to speculate on its exact affinities. In our Western and Southern States, species of perch, brook trout, the siscowet, lake white-fish, species of *Catostomus* and *Pomotis*, and other fresh water fishes, are infested with different species of Lernæans, and there is no more reason for regarding *Cauloxenus* as a "marine form" than any of these parasites. As well might we call a *Cambarus* or a *Crangonyx* a marine form because the great majority of the species of the orders to which they belong are marine. Considering the crustaceans alone, I can see no reason for supposing that the fauna of the caves of Kentucky and Indiana has been derived from any other source than the recent fauna of the surface of the neighboring region.

17. *United States Commission of Fish and Fisheries. Part II. Report of the Commissioner for* 1872 *and* 1873, *with Supplementary Papers.* 8vo, cii, 808 pp., with 37 plates and four maps. Washington, D. C., 1874. Received April, 1875.—In this very valuable report Professor S. F. Baird, the Commissioner, has presented us with a vast amount of information concerning the fresh-water fishes and fisheries of the United States and other countries, together with extended accounts of what has been accomplished in the way of artificial propagation of the fishes, and their introduction into rivers and lakes in all parts of the United States, whether by the commissioners of the various States, or under his own authority. The scope of the work may be seen from the following summary of contents:—Inquiry into the decrease of the food fishes; Action in regard to propagation of food-fishes (shad,

Maine salmon, Rhine salmon, California salmon, white-fish); Multiplication of fish in general, including a history of fish-culture and the various modes of propagating fish of different kinds. The preceding subjects are treated in the special report of the Commissioner. In thirty-four supplementary papers the following subjects are treated: The fisheries of the Great Lakes, and the species of Coregonus, or white-fish, by J. W. Milner; Descriptions of the North American species of salmon and trout, by George Suckley; The Salmon of the Danube, or the hucho, and its introduction into American waters, by B. Hessel; Report of operations, in 1873, at the U. S. hatching establishment on the McCloud River, and on the California Salmonidæ generally, by Livingston Stone; several interesting papers on the salmon and trout of other parts of the United States and Canada, by Mr. Stone, Chas. Lanman, C. G. Atkins, A. C. Hamlin, A. S. Adams, Dr. H. C. Yarrow, and others; several valuable papers giving accounts of the shad and the shad fisheries in all the principal rivers, both southern and northern, together with accounts of the various experiments made in the artificial increase of shad; and a detailed account by Mr. Milner of the mode of propagation and extensive introduction of young shad into the various rivers and lakes, by the U. S. Commissioner; also a detailed history of fish culture, both in Europe and this country, and descriptions of the various methods and apparatus. Appendix E. is devoted to papers on obstructions preventing fishes from ascending various rivers, and on fish-ways, &c, by C. G. Atkins, E. M. Stilwell, M. C. Edmunds, M. McKennie, J. F. Ingalls, and J. W. Milner. Appendix F is devoted to invertebrate Zoology, and includes a descriptive paper on the higher fresh-water Crustacea of the northern United States, and one on crustacean parasites of fishes, with descriptions and figures of a number of new species, by S. I. Smith; a synopsis of the fresh-water leeches, by A. E. Verrill; Sketch of the invertebrate fauna of Lake Superior, by S. I. Smith; Food of fresh-water fishes, by S. I. Smith; Natural History of the gourami, by Theodore Gill; Notes on the grayling (*Thymalus*) of North America, by J. W. Milner. Also several miscellaneous papers relating to temperatures of the Gulf of Mexico; Fish-culture; Bibliography of reports relating to the fisheries, etc. The plates illustrate a great variety of traps, pounds, weirs and other devices for capturing fishes; fish-ways; hatching apparatus; crustacea; aquatic insect larvæ; the gourami, etc. V.

18. *On some Parasitic Worms*, by Dr. LEIDY.—Dr. Leidy has identified the *Ascaris mystax* as an intestinal worm of a Bengal tiger. The species has been found "in many other feline species, including the domestic cat and lion."

A long thread-worm from an apple, submitted to Dr. Leidy, was found by him to be the *Mermis acuminata*, a species that is parasitic in the larvæ of many insects, including the codling-moth, or fruit-moth, of the apple. He states that "twenty-five years ago he described a worm (Proc. 1850, 117) belonging to the collec-

tions of the Academy, and labelled it as having been obtained from a child's mouth, which was evidently the same species. It having been in a child's mouth, is probably to be explained by supposing that the child had eaten an infected apple."

Two specimens of a tape worm, Tænia, were obtained by Dr. Leidy from the stomach of an Australian Wombat. He names it *T. bipapillosa.* An Australian Whallabee afforded, from its peritoneal cavity, a *Filaria*, which he has named *F. spelæa.*—*Proc. Acad. Nat. Sci.*, 1875, 14, 17.

19. *Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, für die Jahre* 1872, 1873, *II und III Jahrgang.* Large 4to, with 12 plates and a chart. Berlin, 1875.—This report is a valuable contribution to the physical and biological history of the European seas. It consists of five parts. The first, upon the Physics of the Seas, is by Dr. H. A. Meyer. It discusses very fully the physical features of the waters of the North Sea, observed during the cruise of the "Pommerania," and especially the temperature and specific gravity. The instruments used are described and figured, and the chart of the North Sea gives the track of the expedition and the location of the various stations. The waters near the coasts of England, Scotland, and Norway were explored, as well as those of Holland. The second part, by Prof. Oscar Jacobsen, relates to the chemical composition of the sea-waters. The third part consists of a report on the marine botany, by Dr. P. Magnus. He gives a catalogue of the algæ, with their distribution, etc., and two plates. The fourth part is a report on the Diatomaceæ, by Adolf Schmidt; it is illustrated by three beautiful plates. The fifth part is devoted to zoology. It includes a report on the Rhizopods, by F. E. Schulze, with figures; on the Sponges, by Oscar Schmidt, with a plate; on Cœlenterata, with a plate, by F. E. Schulze; on Echinoderms, by Karl Mobins and Butchli; on Worms, with a plate, by Karl Mobins. Quite a number of new forms are described in several of the groups. Among the new Rhizopods there is a new genus and species called *Astrodiscus arenaceus*, which appears to be very closely related to a singular species,* evidently of the same genus, which occurs very abundantly on the sandy bottoms off the New England coast, in fifteen to forty fathoms. We have dredged it during the four seasons past in the Bay of Fundy, off Casco Bay, in Vineyard Sound, and off Fisher's Island. It consists of a flat, sand-covered, disk-like body, with a variable number (usually five to nine) of irregular projections radiating from the periphery, and emitting, during life, irregularly branching pseudopodia. Our species grows to nearly a fourth of an inch in diameter, and scarcely differs from the figures of *A. arenaceus*, except in being usually covered by coarser grains of sand, and in having the projections a little more irregular, and often branched.

V.

* See also the writer's Report on Invertebrata, in First Report of U. S. Commissioner of Fish and Fisheries, p. 503, 1873.

20. *Illustrated Catalogue of the Museum of Comparative Zoology.* No. VIII. *Zoological Results of the Hassler Expedition.* II, *Ophiuridæ and Astrophytidæ, including those dredged by the late Dr. Wm. Stimpson;* by THEODORE LYMAN. 34 pp., with cuts and five plates. Jan., 1875.—This work contains a list of 76 species collected by the Hassler expedition, and by Dr. Stimpson, in the Gulf of Mexico. Of these, 19 species were undescribed. Our knowledge of the distribution of the known species, both geographically and in depth, is much extended by this catalogue, while several genera are added to the West Indian fauna, among which is the northern genus *Ophioscolex*, of which a new species (*O. Stimpsonii*) is described, from 240 fathoms off Sombrero Key. The other new species belong to *Ophiomusium*, *Ophiozona*, *Ophioceramis*, *Ophiacantha* (three species), *Ophiomitra*, *Amphiura* (four new species, with notes on known species), *Ophiocnida*, *Ophioplax* (gen. nov.), *Astrotoma* (gen. nov.), *Astroschema*, *Astrophyton* (two species). An analytical table of the six recognized genera of simple armed Astrophytons is given on page 26, and also of the five species of *Astroschema*. V.

21. *The Elements of Embryology;* by M. FOSTER and FRANCIS M. BALFOUR. 8vo, 272 pp., with 71 cuts. Macmillan & Co., 1874.—In this work the authors have given a very complete and detailed account of the development of the chick, from the egg up to the period of hatching. The work contains a large amount of original matter, and the different views on many points are freely discussed. At the end a chapter is devoted to practical instructions for studying the embryology of birds. The book forms an excellent introduction to the general study of embryology, as well as a very useful manual for the embryology of birds. V.

22. *Nature and Life; Facts and Doctrines relating to the Constitution of Matter, the new Dynamics, and the Philosophy of Nature;* by FERNALD PAPILLON; translated from the second French edition by A. R. Macdonough. New York: D. Appleton & Co., 1875.—This book consists of a series of essays, which, in addition to the general subjects indicated in the title, discuss the constitution of Living Beings; the relations of Life to Light, Heat, Electricity, Odors, Medicaments, Ferments, etc. There are also essays on Animal Grafts and Regenerations; Great Epidemics; the Physiology of Death; Heredity in Physiology, in Medicine, and in Psychology. These essays are written in a popular style and cannot fail to interest and instruct a large class of intelligent readers. V.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On Ancient Cave-dwellings in Kentucky;* by F. W. PUTNAM. —That some of the caves were used as places of, at least, temporary residence, was conclusively shown by my exploration of Salt Cave, which proves important in revealing a new phase in American archæology. This cave approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the

principal avenues, for several miles, were to be traced the ancient fire-places both for hearths and lights. For the latter purpose, small piles of stones were made with a hole in the center of the pile to receive the bundle of dried fagots perhaps smeared with grease. Bundles of these fagots, tied up with twisted bark, were found in several places in the cave; and canereeds, probably the remains of ancient torches of the same character with those found in the Mammoth, Short, and Grand Avenue Caves, were also very abundant.

The most important discovery in this cave, however, was made in a small chamber, about three miles from the entrance, first noticed by my guides, Messrs. Cutlip and Lee. On the dry soil of the floor were to be seen the imprints of the sandaled feet of the former race who had inhabited the cave, while a large number of cast-off sandals were found, neatly made of finely-braided and twisted leaves of rushes.—*Eighth Annual Rep. Peabody Museum of Archæology and Ethnology*, Cambridge, 1875.

2. *The catastrophe of the Zenith.*—On the morning of the 16th of April last, under the auspices of the Academy of Sciences, the *Zenith*, containing the three experienced aeronauts, Captain Sivel, Crocé-Spinelli and Gaston Tissandier, and well equipped for scientific work, started on its ascent from the gas works of La Villette, Paris. By 1 o'clock, at noon, they had reached an altitude exceeding 5,000 meters, the barometer marking a pressure of 400 millimeters, and the thermometer 5° C. They had oxygen in bags for breathing in the upper rarefied air, and found it very beneficial. At 1^h 20′ the barometer marked 320 mm., showing an altitude of 7,000 meters; the temperature was −10° C., and soon afterward 7,400, with the temperature −11° C. Sivel and Crocé were already pale and very feeble. By mutual consent Sivel with his knife cut the cords which kept closed three sacs of ballast of 25 kilograms each that were hanging outside. The three sacs emptying themselves, the balloon ascended rapidly, and near 1^h 30′ all three of the aeronauts had fainted. Tissandier, as his consciousness was leaving him, read from the barometer 280 mm., but was already too much paralyzed to speak out his thought—8,000 meters. Tissandier and his friends partially revived, as the balloon was making a very rapid descent; but again all became asphyxiated. The survivor supposes that more ballast was probably dropped by one of them to prevent a fatal descent, and up the balloon went. At 3 o'clock the balloon was again descending rapidly, and Tissandier became conscious; and at 4 o'clock it struck the earth at Ciron near Le Blanche with a severe shock. Sivel and Crocé were dead, their faces black and their mouths full of blood. The greatest height reached, as indicated by the self-registering barometer, was 8,540 to 8,600 meters. The lessons taught to science are: that man cannot safely make a rapid balloon ascent to an altitude of 8,000 meters; that the only chance for reaching alive that altitude in a balloon is by making the rate of ascent above 7,000 meters very slow, giving 12 hours at least

to the next 1,000 meters, and a rate half as fast for the meters beyond; that better arrangements for carrying up air or oxygen to supply the breathers may be of service; that man reaches soon the upward limit of atmospheric investigation.

3. *Protracting Sextant.*—At a recent meeting of the California Academy of Sciences, Mr. T. J. Lowry, of the U. S. Coast Survey, described a new instrument invented by him which may prove of the highest value in surveying, especially in hydrographic surveying. It is based upon the principles of the common sextant, but by it *two* adjacent angles can be at once measured by one observer. Immediately after the observation, moreover, the instrument without change can be laid as a protractor upon the chart, and the place of the observer pricked down, the principle involved being that of the "three point problem."

4. *Mean Height of Europe.*—Dr. GUSTAV LEIPOLDT, in a recently published work on the "Mean Height of Europe," after an elaborate calculation founded on a broad basis of measurement, concludes that it is 296·838 meters, 92 meters higher than the calculation of A. von Humboldt, who indeed made out the average altitude of all the land on the earth to be about 308 meters. The mean height of Switzerland Leipoldt makes to be 1299·91 meters, while that of the Netherlands is only 9·61 meters. That of Great Britain is 217·70. Further interesting details will be found in the April number of Petermann's Mittheilungen.—*Nature*, April 15.

5. *Smithsonian Report for* 1873.—The papers in the Appendix to this Report, which give it special scientific value, are the following: Biographies of BABBAGE, AGASSIZ, TORREY, G. GIBBS; J. C. DALTON on the origin and propagation of disease; HELMHOLTZ on mathematical theories; CLERK MAXWELL on action at a distance; B. A. GOULD on the Cordoba Observatory; E. MAILLY, estimate of the population of the world; A. MORIN on warming and ventilating occupied buildings; E. L. DE FOREST, additions to a memoir on methods of interpolation applicable to the graduation of irregular series; SCHUMAKER on the Kjökken-Möddings of N. W. America; H. BERENDT on a grammar and dictionary of the Cavil language; H. GILMAN on the mound-builders and platycnemism in Michigan; T. M. PERRINE on the antiquities of Union Co., Illinois; W. H. DALL on explorations on the western coast of N. America; W. M. PIERSON on the discovery of a large meteorite in Mexico; F. R. BRUNOT on the habits of the Beaver; W. S. JEVONS on a national library; and a list of Prize Questions issued by Scientific Societies.

6. *Expedition for the Geological and Geographical Survey of the Territories, for* 1875.—The amount appropriated by the last Congress for the U. S. Geological and Geographical Survey of the Territories under the direction of F. V. Hayden was $75,000 for field work, and $20,000 for engraving illustrations, maps, &c. Six parties will take the field in various portions of Colorado about the first of June. Mr J. T. Gardner will carry the primary triangulation of the area between lat. 36° 45′ and 39° 15′; long.

104° 30′ and 109° 30′. Mr. A. D. Wilson, chief of field party No. 1, will survey an area in the southern part of Colorado, with a portion of northern New Mexico lying between lat. 36° 45′ and 37° 45′, long. 105° and 108°. Mr. Henry Gannet, in charge of field party No. 2, will occupy the area between lat. 38° and 39° 15′ and long. 108° and 109° 30′.

Field party No. 3 will survey the area in the southwestern Colorado between lat. 36° 45′ and 38° and long. 108° and 109° 30′. Field party No. 4 will complete unfinished areas in central and eastern Colorado. The photographic party under Mr. Jackson will make a study of the ancient rivers in southern and southwestern Colorado and also some special studies of remarkable mountain scenery in various portions of the Territory.

It is expected that at least four of the six sheets of the Colorado atlas will be completed this season, with portions of the other two. The maps will be issued as geological as well as topographical maps, in the final atlas.

7. *National Academy of Sciences.*—The following is a list of the papers read at the session of the National Academy of Sciences, held on the 20th to the 22nd of April, 1875:

Results derived from an examination of the U. S. Weather Maps for 1872–3–4; E. Loomis.

Notes on observations of the transit of Venus; G. Davidson.

On an improvement of the present civil or Gregorian calendar; J. P. Bradley.

Results of experiments on the set of rectangular bars of wood, iron and steel, resulting from a transverse stress; W. A. Norton.

Note on Goldschmid's Aneroid Barometer; J. E. Hilgard.

Progress of Second Geological Survey of Pennsylvania; J. P. Lesley.

Orography of the Catskill group of mountains; A. Guyot.

Report of the Committee on Weights, Measures and Coinage; F. A. P. Barnard.

On the observations of contacts in transits of Venus and Mercury; S. Newcomb.

New formula for the deflections of rectangular bars or beams, resting on supports and subjected to a transverse stress: W. A. Norton.

Size of the brain in extinct mammals; O. C. Marsh

Account of researches in Solar Physics made at the Allegheny Observatory during the past four years; S. P. Langley.

Use of the Stereoscope in the study of Solid Geometry; James D. Warner.

On the interpolation of a change of sign by passage through infinity of a mathematical function expressive of a physical phenomenon; a curious particular case in the theory of tides; J. G. Barnard.

Discussion of the Laws of Atmospheric Circulation, by Prof. James H. Coffin (now deceased); Selden J. Coffin.

Influence of Arsenical compounds upon Vegetation; Wm. McMurtrie.

Preliminary account of results of a Magnetic Survey, made at the charge of the Bache Fund; J. E. Hilgard.

Relations of some of our ancient Fossil Fishes to living Forms; J. S. Newberry.

On areas of Cold; by A. Woeikof.

8. *Mastodon of Otisville, Orange County, N. Y.*—Prof. Marsh has secured, for the Peabody Museum of Yale College, the skeleton of a large mastodon, exhumed by Mr. A. Mitchell on his grounds at Otisville, seventy-five miles from New York and within a mile and a half of the Erie Railroad. The bones were found on and in clay beneath a deep bed of muck, and are in an excellent state of preservation. This Otisville mastodon is the sixth that has been found in the swamps of Orange County.

9. *Statistical Atlas of the United States, based on the results of the Ninth Census*, 1870, with contributions from many eminent men of science and from several departments of the Government. Compiled, under authority of Congress, by FRANCIS A. WALKER, M.A., Superintendent of the Ninth Census, Professor of Political Economy and History in the Sheffield Scientific School of Yale College. In large folio. (Julius Bien, Lith.)—The publication of Parts 2 and 3 of this Atlas has been already announced on page 74 of this volume. Part 1 completes the great work, and in a most satisfactory manner. Among its maps there is one of great interest showing the distribution of wood-land in the United States, by Prof. Wm. H. Brewer; another giving a hypsometric view of the surface, prepared from data furnished by Prof. Guyot and C. A. Schott of the U. S. Coast Survey; others illustrating the meteorological characteristics of the country; one giving the distribution of the Coal fields, compiled by Prof. C. H. Hitchcock; and one which is an excellent geological chart of the United States, 19 by 28 inches in size, by Profs. C. H. Hitchcock and W. P. Blake. This geological chart has been prepared with care and is beautiful in its lithography and coloring. In fact, the whole work is highly creditable to the photolithographic establishment of Mr. Bien. The maps are accompanied by many pages of text giving explanatory, descriptive and statistical information. We defer to another number a more extended notice of the Atlas.

10. *Popular Science Library.*—Under this title D. Appleton & Co. are publishing a valuable series of small works in Science. The following have been issued: *Health*, by EDWARD SMITH, F.R.S.; *The Natural History of Man*, by Prof. A. DE QUATREFAGES; *The Science of Music*, by SEDLEY TAYLOR; *Outline of the Evolution Philosophy*, by Dr. E. CAZELLE, with an Appendix by E. L. YOUMANS, M.D., on *Herbert Spencer and the Doctrine of Evolution*, giving a brief exposition of the views and claims of Spencer.

11. *New York Academy of Sciences.*—The Lyceum of Natural History of New York has recently changed its name to New York Academy of Sciences.

12. *Geological Society of London.*—Dr. F. V. HAYDEN has been recently elected Foreign Correspondent of the Geological Society of London.

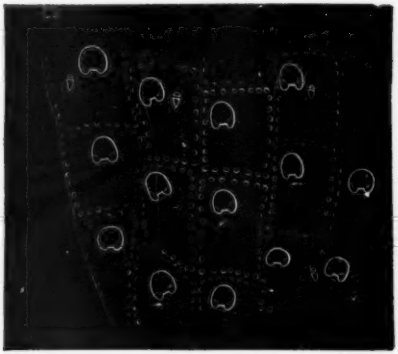
Life of Murchison, by Archibald Geikie. 2 vols. London, 1875. (Murray.)

Statement and Exposition of certain Harmonies of the Solar System, by Stephen Alexander, Prof. Astron. Coll. of New Jersey. 96 pp. 4to. 1875. Smithsonian Contributions to Knowledge, No. 280.

Half-hour Recreations in Natural History of Estes and Laureat. Boston. 72 to 80 pages each.—Half-hours with Insects, Parts 6 and 7, by A. S. Packard, Jr.—The Glacial Epoch of our Globe, by Alexander Braun.—The Sun and the Earth, by Prof. Balfour Stewart, F.R.S.; Force electrically explained, by J. W. Phelps.—The first volume of these Half-hour Recreations, numbering 478 pages, has been issued by the publishers in a handsome form.

Catalogue of the Fishes of the East Coast of North America, by Theodore Gill. Washington, 1875. 52 pp. 8vo.—Smithsonian Miscellaneous Collections.

Astronomy by J. N. Lockyer, being No. VII of Science Primers, edited by Professors Huxley, Roscoe and Balfour Stewart. 120 pp. 16mo, with many fine illustrations. 1875. (D. Appleton & Co.)



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